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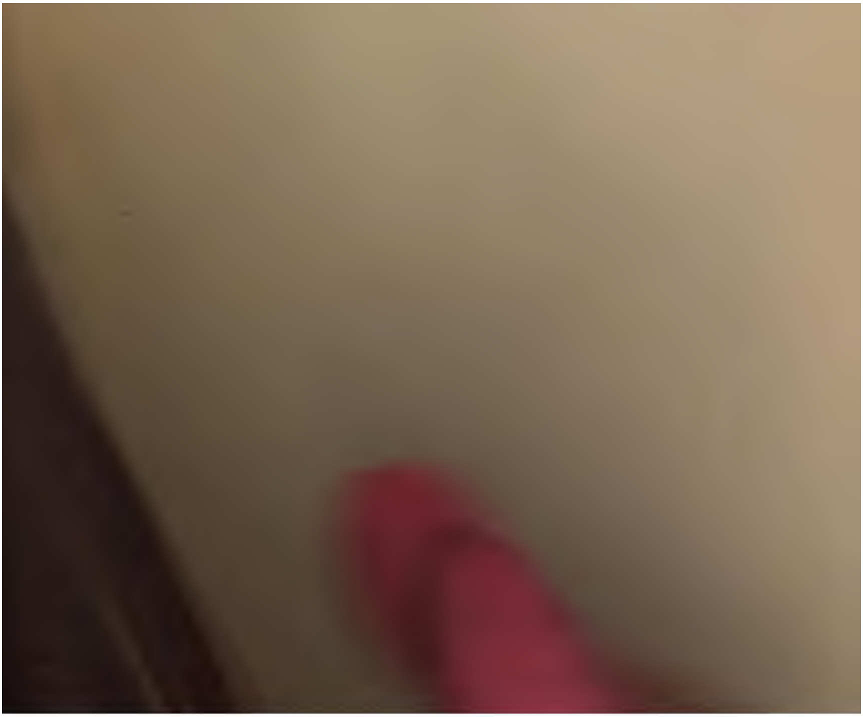

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A

MANUAL OF BOTANY

BEING

AN INTRODUCTION

TO THE

STUDY OF THE STRUCTURE, PHYSIOLOGY, AND CLASSIFICATION OF PLANTS.

BY

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REGIUS KEEPER OF THE ROYAL BOTANIC GARDEN.

NEW EDITION, REVISED BY THE AUTHOR.

Illustrated by Numerous Engravings.

EDINBURGH:
ADAM AND *CHARLES* BLACK.
1863.

7.

TO

ROBERT KAYE GREVILLE, LL.D.

AS A SMALL BUT SINCERE

MARK OF REGARD FOR HIS EMINENCE AS A BOTANIST,

OF GRATITUDE

FOR HIS KIND BOTANICAL SERVICES,

AND OF ESTEEM

FOR HIS CHARACTER AS A CHRISTIAN FRIEND,

THE FOLLOWING PAGES ARE

DEDICATED BY

J. H. BALFOUR.

PREFACE.

In drawing up this Manual of Botany, the object has been to give a comprehensive, and, at the same time, a condensed view of all departments of the science, including the microscopical structure of plants and their morphology, the functions of their various organs, their classification and distribution over the globe, and their condition at various geological epochs. Care has been taken to notice the plants used for commercial or economical purposes, and particularly those having medicinal properties. The principles of adaptation and order which prevail in the vegetable kingdom have been prominently brought into view, with their bearings on symmetry and arrangement.

The physiology of plants has been considered in connection with the anatomical structure of their different organs, and the recent views in regard to the embryogenic process in flowering and flowerless plants have been brought under notice.* In the department of classification, the system of De Candolle has been more or less completely followed, and the characters of the natural orders have been briefly given. It has been shown that the great object of classification is to arrange plants according to their affinities in all important particulars, and thus to trace, what may be considered to be, the plan of the Almighty and all-wise Creator. At the same time, in all systems it is necessary to have artificial means to aid in the study of genera and species. Such means, like an index, must be easily applied so as to assist the beginner in his studies. It is only the Botanist, who has an extended knowledge of the vegetation of the globe, who has examined the effects produced on vegetation by climate and other circumstances of existence, and who has studied aberrant forms in connection with natural orders, that can take a correct view of the alliances of plants.

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* In the Author's "Class Book of Botany," the physiological department of Botany is very fully considered.

The divisions of geographical and palæontological Botany are still in an imperfect state, and are undergoing constant changes from the discoveries of naturalists in various parts of the world. All that has been attempted in this volume is to give a very general outline of these subjects, and to call the attention of the student to the points which still require elucidation. In the Appendix will be found a description of the microscope, of its use as an instrument of research in histological Botany, and of the mode of making vegetable preparations. There are also added directions as to the collecting of plants and the formation of an herbarium, with hints as to alpine travelling, and as to the examination of a country in a botanical point of view. A full glossary of the nary botanical terms is likewise given.

The study of Botany is well fitted to call the observant faculties into active exercise. It teaches the student to mark the differences and resemblances between objects, and leads to habits of correct observation and diagnosis. In the present day there is a growing feeling of its importance in mental culture, and a tendency to include it as an optional class in the curriculum of Arts, as well as in that of Medicine. It is now also taking a place in our school-books, and thus becoming part of the education of the young. It is a science fitted for all ages, for all ranks, and for all seasons. "In youth when the affections are warm and the imagination vivid; in more advanced life when sober judgment assumes the reins; in the sunshine of fortune, and the obscurity of poverty, it can be equally enjoyed. The opening buds of spring; the warm luxuriant blossoms of summer; the yellow bower of autumn; and the leafless desolate groves of winter, equally afford a supply of mental amusement and gratification to the Botanist." It is hoped that the present Manual may aid in the promotion of a science, the study of which is so well calculated to contribute to the enjoyment and well-being of mankind. The examination of the plants which clothe the surface of the globe, of the lilies of the field, and of the meanest moss or lichen in our path, is well fitted to call forth exalted views of the eternal power and Godhead of Him who hath made all these for His own glory, and whose providential care extends to the clothing of the grass of the field, which to-day is, and to-morrow is cast into the oven.

27 Inverleith Row, Edinburgh,
April 1863.

INTRODUCTORY REMARKS.

It has too often been supposed that the principal object of Botany is to give names to the vegetable productions of the globe, and to arrange them in such a way that these names may be easily found out. This is a most erroneous view of the science, and one which was perhaps fostered by some of the advocates of the Linnean system. The number of species collected by a botanist is not considered now-a-days as a measure of his acquirements, and names and classifications are only the mechanism by means of which the true principles of the science are elicited. The views in regard to a natural system proposed by Ray and Jussieu did much to emancipate Botany from the trammels of artificial methods, and to place it in its proper rank as a science. Their labours have been ably carried out by De Candolle, Brown, Endlicher, Lindley, Hooker, Arnott, Bentham, and others. The relative importance of the different organs of plants, their structure, development and metamorphoses, are now studied upon philosophical principles. The researches of Gaudichaud, Mirbel, and Trecul, as to the structure and formation of wood; the observations of Schleiden and Mohl on cell development; the investigations of Brown, Schleiden, Fritzsche, Amici, Hofmeister, Tulasne, and others, into the functions of the pollen, the development of the ovule, and the formation of the embryo; the experiments of Schultz, Decaisne, and Thuret, on the movements observed in the cells, vessels, and spores of plants, and various other physiological inquiries, have promoted much our knowledge of the alliances and affinities of plants. Thus the labours of vegetable anatomists and physiologists all tend to give correct views of the relation which plants bear to each other, of the laws which regulate their development, and of the great plan on which they were formed by the Creator.

There is a tendency, however, to speak of the laws of nature as if they were in themselves executive, and this has led to erroneous views of the system of the universe. Many attempt to shut out God from His works by this means. The Creator is regarded as looking at the development of His plan, and watching its progress, but not requiring to exercise constant and unwearied superintendence of the minutest event. Nay, even when He creates animals with certain instincts, and plants with certain functions, He is represented like an imperfect workman taking a lesson from the operations of the beings which He has made, and which, by their own efforts of selection, or by their own struggles for existence, complete what the Creator had set on foot. A certain mechanism is set a-going in some unknown way, and it continues to work according to definite laws. But what are laws, unless there is some one to carry them out. The great Author of these laws must be always working in them and by them, and upholding them in their integrity and efficiency. No doubt the Creator is a God of order and method, and the operations of His wisdom and power are displayed in what we call laws. The execution of these laws, however, is just as wonderful and miraculous as is a fiat of creation, and requires equally the exercise of Almighty power. The uniformity of nature depends on the wisdom that made these laws and adapted them to all the varying conditions of the universe. In the course of Providence, however, there are every now and then marked events which seem to be at variance with this uniformity, as when a deluge overwhelms mankind, or when a sudden convulsion destroys the cities of the plain. Such events show that all things do not continue as they were from the beginning of the creation. Those who look for a progressive development and a gradual and eternal advance towards perfection in the living beings which cover the earth, without further creative fiats or movements *per saltum*, forget, in their lations, that a time is coming when, as the Apostle says, "the and the works that are therein shall be burned up," and then shall there be ushered in "a new earth," wherein righteousness shall dwell. We cannot but honour the man, who, by his genius and talent, has been enabled to develop one of the great laws of nature, and who feels and acknowledges that he has been the humble instrument to lift the veil to a certain extent which conceals the workings of the Almighty; but we have no sympathy with that discoverer in science, who, puffed up with intellectual superiority, puts the laws which he has elucidated in the place of the Creator, whose personality and ever-working omnipresence he ignores.

In studying, therefore, the laws which are exhibited in the economy of living beings, let us never in the pride of science and philosophy forget Him, who not only created all things but upholds all things, and by whom all things consist. While we apply ourselves with the earnestness of zealous students to examine those wondrous works which are sought out of all that have pleasure therein, let us take every thing in connection with that Word which is the sole record of Truth, and which, as coming from the God of nature, must be in perfect harmony with the laws of nature.

The Botanist, in accomplishing the ends he has in view, takes an enlarged and comprehensive view of the vegetation with which the earth is clothed. He considers the varied aspects under which plants appear in the different quarters of the globe, from the Lichen on the Alpine summits, or on the Coral reef, to the majestic Palms, the Bananas and Baobabs of tropical climes—from the minute aquatics of our northern pools to the gigantic Victoria of the South American waters—from the parasitic fungus, only visible by the aid of the microscope, to the enormous parasite discovered by Raffles in the Indian Archipelago.

It is interesting to trace the relation which all these plants bear to each other, and the mode in which they are adapted to different climates and situations. The lichens are propagated by spores or germs so minute as to appear like thin dust, and so easily carried by the wind that we can scarcely conceive any place which they cannot reach. They are the first occupants of the sterile rock and the coral-formed island—being fitted to derive the greater part of their nourishment from the atmosphere and the moisture suspended in it. By degrees they act on the rocks to which they are attached, and cause their disintegration. By their decay a portion of vegetable mould is formed, and in progress of time a sufficient quantity of soil is produced to serve for the germination of the seeds of higher plants. In this way the coral island is, in the course of years, covered with a forest of coco-nut trees. Thus it is that the most despised weeds lay the foundation for the denizens of the wood; and thus, in the progress of time, the sterile rock presents all the varieties of meadow, thicket, and forest.

The Creator has distributed his floral gifts over every part of the globe, from the poles to the equator. Every climate has its peculiar vegetation, and the surface of the earth may be divided into regions characterized by certain predominating tribes of plants. The same thing takes place on the lofty mountains of warm climates, which may be said to present an epitome of the horizontal distribution of plants. Again, if we descend into the bowels of the earth, we find there traces of vegetation—a vegetation, however, which flourished at distant epochs of the earth's history, and the traces of which are seen in the coal, and in the fossil plants which are met with in different strata. By the labours of Brongniart especially, these fossil remains have been rendered available for the purposes of science. Many points have been determined relative to their structure, as well as in regard to the climate and soil in which they grew, and much aid has been afforded to the Geologist in his investigations.

The bearings which Botany has on Zoology are seen when we consider the lowest tribe of plants, such as Diatomaceæ. These bear a striking resemblance to the lowest animals, and have been figured as such by Ehrenberg and others. The observations of
n Conjugation have confirmed the view of the vegetable
nany of these bodies. There appear, however, to be
ctions which occupy a sort of intermediate territory

between the animal and vegetable kingdom, and for the time being the Botanist and Zoologist must consent to join occupancy.

The application of botanical science to Agriculture and Horticulture has of late attracted much attention, and the chemistry of plants has been carefully examined by Liebig, Mülder, and Johnston. The consideration of the phenomena connected with germination, and the nutrition of plants, has led to important conclusions, as to sowing, draining, ploughing, the rotation of crops, and the use of manures.

The relation which Botany bears to Medicine has often been misunderstood. The medical student is apt to suppose that all he is to acquire by his botanical pursuits, is a knowledge of the names and orders of medicinal plants. The object of the connection between scientific and mere professional studies is here lost sight of. It ought ever to be borne in mind by the medical man, that the use of the collateral sciences, as they are termed, is not only to give him a great amount of general information, which will be of value to him in his after career, but to train his mind to that kind of research which is essential to the student of medicine, and to impart to it a tone and a vigour which will be of the highest moment in all his future investigations. What can be more necessary for a medical man, than the power of making accurate observations, and of forming correct distinctions and diagnoses? These are the qualities which are brought into constant exercise in the prosecution of the botanical investigations, to which the student ought to turn his attention, as preliminary to the study of practical medicine. In the prosecution of his physiological researches, it is of the highest importance that the medical man should be conversant with the phenomena exhibited by plants. For no one can be reckoned a scientific physiologist who does not embrace within the range of his inquiries all classes of animated beings; and the more extended his views, the more certain and comprehensive will be his generalizations.

To those who prosecute science for amusement, Botany presents many points of interest and attraction. Though relating to living and organized beings, the prosecution of it calls for no painful experiments nor forbidding dissections. It adds pleasure to every walk, affords an endless source of gratification, and it can be rendered available alike in the closet and in the field. The prosecution of it combines healthful and spirit-stirring recreation with scientific study; and its votaries are united by associations of no ordinary kind. He who has visited the Scottish Highlands with a botanical party, knows well the feelings of delight connected with such a ramble—feelings by no means of an evanescent nature, but lasting during life, and at once recalled by the sight of the specimens which were collected. These apparently insignificant remnants of vegetation recall many a tale of adventure, and are associated with the delightful recollection of many a friend. It is not indeed a matter of surprise, that those who have lived and walked for weeks together in a Highland ramble, who have met in sunshine and in tempest, who have climbed together the misty summits, and have slept in the miserable shielding—should have such scenes indelibly impressed on their memory. There is, moreover, something peculiarly attractive in the collecting of *alpine* plants. Their comparative rarity, the localities in which they grow, and frequently their beautiful hues, conspire in shedding around them a halo of interest far exceeding that connected with lowland productions. The alpine Veronica displaying its lovely blue corolla on the verge of dissolving snows; the Forget-me-not of the mountain summit, whose tints far excel those of its namesake of the brooks; the Woodsia, with its tufted fronds, adorning the clefts of the rocks; the snowy Gentian concealing its eye of blue in the ledges of the steep crags; the alpine Astragalus enlivening the turf with its purple clusters; the Lychnis choosing the stony and dry knoll for the evolution of its pink petals; the Sonchus, raising its stately stalk and azure heads in spots which try the enthusiasm of the adventurous collector; the pale-flowered Oxytropis confining itself to a single British cliff; the Azalea forming a carpet of the richest crimson; Saxifrages, with their white, yellow, and pink blossoms, ing the sides of the streams; the Saussurea, and Erigeron crowning the rocks with their purple and pink capitula; the pendent Cinquefoil blending its yellow flowers with the white of the alpine Cerastiums and the bright blue of the stony Veronica; the stemless Silene giving a pink and velvety covering to the decomposing granite; the yellow Hieracia, whose varied transition forms have been such a fertile cause of dispute among Botanists; the slender and delicate grasses, the chickweeds, the carices, and the rushes, which spring up on the moist alpine summits; the graceful ferns, the tiny mosses, with their urn-like thecæ, the crustaceous dry lichens, with their spore-bearing apothecia; all these add such a charm to Highland Botany, as to throw a comparative shade over the vegetation of the plains.

Many are the important lessons which may be drawn from the study of plants, when prosecuted in the true spirit of Wisdom. The volume of Creation is then made the handmaid of the volume of Inspiration, and the more that each is studied, the more shall we find occasion to observe the harmony that subsists between them. It is only Science, falsely so called, which is in any way opposed to Scripture. Never, in a single instance, remarks Gaussen, do we find the Bible in opposition to the just ideas which Science has given us regarding the form of our globe, its magnitude, its geology, and the productions which cover the surface. "The invisible things of God from the creation of the world are clearly seen, being understood by the things that are made, even his eternal power and Godhead." The more minutely we examine the phenomena of the material world, and the more fully we compare the facts of Science with Revealed Truth, the more reason shall we have to exclaim, in adoring wonder, with the Psalmist of old, "O Lord! how manifold are thy works! in wisdom hast thou made them all; the earth is full of thy riches."

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BOTANY.

PART I.

VEGETABLE ANATOMY, ORGANOGRAPHY, AND PHYSIOLOGY.

1. BOTANY is that branch of science which comprehends the knowledge of all that relates to the Vegetable kingdom. It embraces a consideration of the external configuration of plants, their structure, the functions which they perform, the relations which they bear to each other, and the uses to which they are subservient. It has been divided into the following departments:—1. *Structural Botany*, or *Organography*, which has reference to the textures of which plants are composed, and to the forms of their various organs. 2. *Physiological Botany*, in which plants are considered in their living or active state, and while performing certain vital functions. 3. *Systematical Botany*, or *Taxonomy*, the arrangement and classification of plants. 4. *Geographical Botany*, or the distribution of plants over the globe. 5. *Fossil Botany*, or the nature of the plants found in a fossil state in the various geological formations.

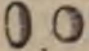
CHAPTER 1.

ELEMENTARY ORGANS, OR VEGETABLE TISSUES.

2. In their earliest and simplest state plants consist of minute vesicles, formed by an elastic transparent membrane, which is composed of a

substance called *Cellulose.* This substance is of general occurrence, and constitutes the basis of vegetable tissues. The chemical formula representing it is either $C^{12} H^{8} O^{8}$, or $C^{12} H^{10} O^{10}$.* It was long considered as essentially a vegetable product, not found in animal structures; but Schmidt, Kölliker, and others, have recently detected it in the tissues of the ascidia, and other molluscous animals. It is allied to starch, into which it is convertible by the action of heat, the addition of sulphuric acid, or caustic potash. It becomes yellow on the addition of iodine, and when acted upon by iodine and sulphuric acid, a blue colour, like that of iodide of starch, is produced. The acid appears to convert the cellulose into starch. The membrane formed by cellulose is permeable by fluids, and becomes altered in the progress of growth, so as to acquire various degrees of consistence. A modification of cellulose occurs in the form of woody matter or lignin. The hard cells in the stone of the peach, and in the shells of other fruits and seeds, consist of cellulose, with deposits of lignin. In the advanced stages of growth, plants consist of two kinds of tissue, *Cellular* and *Vascular*, which, under various modifications, constitute their *Elementary organs.* These, by their union, form the *Compound organs*, by which the different functions of plants are carried on.

3. The elementary organs consist of *vesicles* and *tubes*, varying in form and size, and united in different ways. Vascular structures always indicate the pre-existence of cell growth, but cellular development may go on indefinitely without the formation of tubes. The vesicles are cavities surrounded by a membrane, their length not much exceeding their breadth (fig. 1); while the tubes are similar cavities more or less elongated (figs. 3, 4).



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* These symbols indicate the equivalents of Carbon (C), Hydrogen (H), and Oxygen (O), which enter into the composition of cellulose. For the meaning of these and other chemical symbols, see Chap. II. Sect. 1. Div. 2, on the Food of Plants. P. 113, *et seq.*

Fig. 1. Vesicles or small cells.

SECTION I.—CELLULAR TISSUE.

1.—FORM AND ARRANGEMENT OF CELLS.

4. **Cellular Tissue** is formed by the union of minute vesicles or bladders, called *cells*, *cellules*, or *utricles*. This tissue is often called Parenchyma (παρὰ, through, and ἐγχύω, I infuse). The terms *Parenchymatous*, *Areolar*, *Utricular*, and *Vesicular*, when applied to vegetable tissues, may be considered as synonymous. The individual cells of which this tissue is composed, when allowed to develope themselves equally in all parts of their circumference, are usually of a more or less rounded form (figs. 5, 6, 7); but during the progress of development they frequently become more elongated in one direction than in another (fig. 2), and often assume angular or polyhedral forms (fig. 8).

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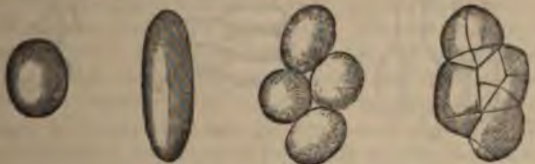
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5. The following names have been applied by Morren, and other authors, to the tissue made up of variously-formed cells:—1. *Parenchyma*, a general name for cellular tissue, but often applied to that consisting of dodecahedral cells (figs. 8, 12, 13), which, when cut in one direction, exhibit an hexagonal form (figs. 14, 15), and hence the tissue is sometimes called *hexagonienchyma* (ἑξαγώνιος, six-angled); it is seen in the pith of the Elder, and in young palm stems. 2. *Sphærenchyma* (σφαῖρα, a sphere), spheroidal cells (fig. 5). 3. *Merenchyma* (μηρύω, to revolve), ellipsoidal cells (fig. 6). 4. *Ovenchyma* (ὠόν, an egg), oval cells. Round, elliptical, and oval cells, are common in herbaceous

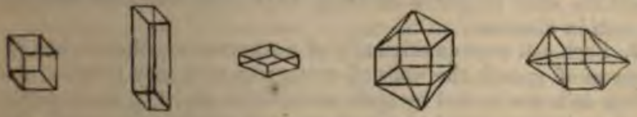
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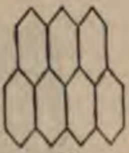
Fig. 2.—Fusiform or spindle-shaped cell. Figs. 3, 4.—Tubes or vessels.
Figs. 5, 6, 7, 8.—Cells, or utricles, separate and combined.
Figs. 9, 10, 11, 12, 13.—Figures representing the forms of cells.

plants. 5. *Conenchyma* (κῶνος, a cone), conical cells, as hairs. 6. *Columnar*, cellular tissue, divided into *Cylindrenchyma* (κύλινδρος, a cylinder), cylindrical cells, as in Chara (fig. 17 *a*), and *Prismenchyma* (πρίσμα, a prism), prismatical cells, seen in the bark of some plants (fig. 10). When compressed, prismatical cells form the *muriform* (*murus*, a wall, like bricks of a building) tissue of the medullary rays of woody stems, and when much shortened they assume a tabular form, constituting *Pinenchyma* (πίναξ, a table), tabular cells (fig. 11), or square cells (fig. 9). 7. *Prosenchyma* (¶ 29), or *Atractenchyma* (ἄτρακτος, a spindle), fusiform or spindle-shaped cells, seen in woody structures (fig. 2). 8. *Colpenchyma*, (κόλπος, a sinus or fold), sinuous or waved cells, as in the cuticle of leaves. 9. *Cladenchyma* (κλάδος, a branch), branched cells, as in some hairs. 10. *Actinenchyma* (ἀκτιν, a ray), stellate or radiating cells, as in Juncus and Musa (fig. 16). 11. *Dædalenchyma* (δαίδαλος entangled), entangled cells, as in some Fungi.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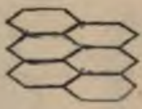
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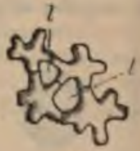

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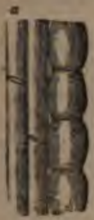
6. The size of cells varies not less than their figure in different plants, and in different parts of the same plant. They are frequently seen from $\frac{1}{300}$, $\frac{1}{500}$, to $\frac{1}{1000}$ of an inch in diameter. In cork, which is cellular, Hooke found more than a thousand in the length of an inch. In the pith of Elder cells $\frac{1}{120}$ of an inch in diameter are seen. In many succulent vegetables, and in the pith of some aquatic plants, large cells ranging from $\frac{1}{50}$ to $\frac{1}{30}$ of an inch in diameter occur. Mohl declares the general average of cells to vary from $\frac{1}{240}$ to $\frac{1}{1200}$, while the cells in spores of Fungi have been computed at $\frac{1}{5000}$ of an inch in diameter.

7. Each cell consists originally of a separate membrane, but in the progress of growth the walls of contiguous cells may become united. When cells are united by their extremities (fig. 17), their partitions are occasionally absorbed so as to form continuous tubes. When cells are united in a rectilinear manner, those in contiguous rows are either directly opposite to each other, that is, are placed at the same height (fig. 18), or are alternate, from being placed at different heights (fig. 19); cells sometimes communicate with each other laterally (fig. 20 *a a*). Isolated cells, as spores of sea-weeds, occasionally

Figs. 14, 15.—Hexagonal cells.
Fig. 16.—*Branching cells of* Vicia Faba. *ll*, Intercellular lacunæ.

have free filaments, or cilia (*cilium*, an eyelash) developed on their surface.



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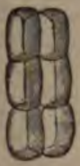

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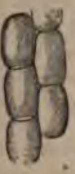

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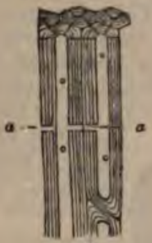

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8. The simplest kinds of plants, as mushrooms and sea-weeds, are composed entirely of cellular tissue, and are called *Cellulares.* The pulpy and succulent parts of all plants contain much cellular tissue, and the object of horticultural operations is to increase the quantity of this tissue in ordinary fruits and vegetables. The pith of trees, and plants during their early development are cellular; so also are cotton and rice-paper. The cell may be considered as the ultimate structural element of all organism. In the simplest vegetable forms, as in unicellular algæ, it is adequate to all the purposes of plant life. Vital operations are carried on in all plants by means of cells, the constitution and functions of which vary according to the nature of the plants and the position in the scale of organization which they occupy. In the higher classes of plants, certain cells are concerned in the secretion of organizable products, which are elaborated by others into new tissues. The life of the higher species of plants results from the regular action of cells, which are of unequal value as regards the formation of new organs and new products. In cells there are observed the absorption and movements of fluids, the elaboration of these by exposure to air and light, and the formation of new cells. Schacht remarks that a plant is composed of one or more cells, and that it is only in the lowest species that the cells are of the same *value;* in other words, are of the same chemical and physical nature, and of the same physiological importance. Even amongst the mushroom and sea-weed orders, it is only the lowest plants which have cells concerned alike in the processes of vegetation and reproduction. The higher plants of these orders are composed of parts having different *values.*

9. In general, no visible openings can be detected in cells, although fluids pass readily into and out of them. Harting and Mülder, however, state, that they have observed perforations in the cells of Hoya carnosa,

Figs. 17, 18, 19.—Cells united together by their extremities.

Fig. 20.—Elongated thickened cells, from *the root of the Date Palm.* *a a*, Canals of communication.

Asclepias syriaca, Cycas revoluta, Virginian spiderwort, and Traveller's joy. In one cell (from a Euphorbia), having a transverse diameter of 0·03777 millimetres,* they counted 45 minute holes. In some mosses, also, openings have been found in the cells.

21

22

10. **Porous or Pitted cells** are those in which the membrane is thickened at certain parts, with thin rounded spots intervening, which, when viewed by transmitted light, appear like perforations or pores (figs. 21, 28). The unequal deposit of the internal encrusting cellulose or woody matter is the cause of this condition. The pores of contiguous cells usually correspond as regards position, and sometimes the membrane becomes absorbed between them, so as to allow a direct communication by means of lateral canals, as is seen in the cells from the root of the Date (fig. 20 *a a*). When porous cells are united end to end, so as to form tubes, they have been denominated *articulated Bothrenchyma* (βόθρος, a pit), on account of their bead-like appearance, and the pits or depressions in their thickened walls (fig. 22.)

11. **Fibrous or Spiral cells** are those in which there is a spiral elastic fibre coiled up in the inside of the membrane (fig. 23). When united they form *fibro-cellular tissue*, or *Inenchyma* (ἶνες, fibres). These cells generally consist of membrane and fibre combined, but the former appears to be sometimes absorbed wholly or partially during the progress of growth. The membrane, in some instances, is easily dissolved by water, and then the elastic close convolutions of the fibre spring out with considerable force, as in the outer covering of the seeds of Collomia and Salvia. Spiral cells abound in many of the Orchidaceous plants, as Oncidiums and Pleurothallis ruscifolia, also in the garden Balsam, in the leaf of the moss called Sphagnum, and in the Cactus tribe. They are also found in the inner covering of anthers, in the spore-cases of many of the lower tribes of plants, and in the coats of the seeds of Acanthodium spicatum and Sphenogyne speciosa. The spiral filaments sometimes exhibit peculiar movements when placed in water.

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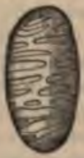
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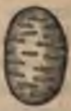
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* A millimetre is about 1-25th of an English inch.

Fig. 21.—Porous cell, from the Elder (*Sambucus nigra*).

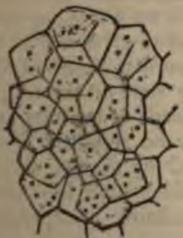
Fig. 22.—Articulated Bothrenchyma, or Taphrenchyma, from Mistleto, having a moniliform appearance. Figs. 23, 24, 25.—Spiral, annular, and reticulated cells, from Mistleto (*Viscum album*).

Fig. 26.—Scalariform and dotted cell, from Elder (*Sambucus nigra*)

The fibre in these cells varies from about $\frac{1}{2000}$ to $\frac{1}{10,000}$ of an inch in diameter; it is solid, and presents either a circular, an elliptic, or a quadrangular section. The coils of the fibre sometimes separate from each other, and become broken up and united in various ways, so as to appear in the form of rings, bars, or dots, thus giving rise to *annular* (fig. 24), *reticulated* (fig. 25), *scalariform* and *dotted* cells (fig. 26), which constitute the *spurious* or *imperfect Inenchyma* of authors. Annular cells are met with in Opuntia; reticulated cells, caused by fibres forming a sort of mesh or network, are seen in the wing of the seed of Swietenia, the pericarp of Picridium tingitanum, the leaf of Sanseviera guineensis, and the pith of Rubus odoratus and Erythrina Corallodendron.

12. In certain parts of plants cells are placed closely together, and compressed so as to touch each other by flat surfaces, filling up space completely, and leaving no intervals; they then form the *perfect Parenchyma* of Schleiden (figs. 8, 27). In lax tissues, however, the cells retain a rounded shape, and then touch each other at certain points only, leaving intervals of various sizes and shapes, and forming the *imperfect Parenchyma* of Schleiden (figs. 7, 28). These intervals, when of moderate size and continuous, are called *intercellular passages* or *canals;* when large, irregular, and circumscribed, *intercellular spaces*, or *Lacunæ* (fig. 16 *l l*).

13. A difference of opinion prevails as to the mode in which cells are united together. Some maintain that the cell-walls in the young state unite together directly, and become agglutinated, more or less, according to their places of contact. Others, as Mohl and Henfrey, hold that there is an intercellular matter which acts as a sort of cement, or *Collenchyma* (κόλλα, glutinous matter). In sea-weeds, the cells, of which the entire plant is composed, are placed at a distance from each other (fig. 29 *a a*), and the intervals are filled up by this intercellular substance (fig. 29 *b*), which thus forms a large part of



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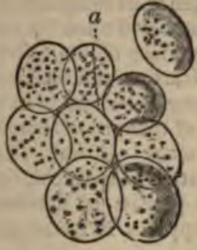

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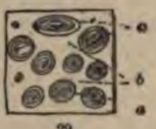
Fig. 27.—Cellular tissue, from pith of Elder.
Fig. 28.—Porous Merenchyma, from Houseleek (*Sempervivum tectorum*), *a*, Intercellular canal.

their bulk. In the higher classes of plants, when the cells touch each other, the layer of intercellular matter must be very thin, except in the intercellular canals or spaces. Mirbel looks upon it as the remains of the mucilaginous fluid in which the cells were originally developed, and which has become thickened to a greater or less degree, as in the root of the Date (fig. 30), where *a a a* indicate the cells, and *b b b* the interposed substance.



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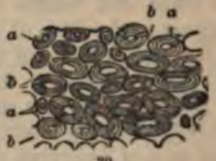

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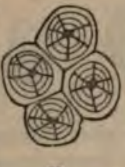
2.—Contents of Cells.

14. The external membrane of cells is composed of the unazotised substance called *Cellulose*, and in their interior a mucilaginous matter is contained, which undergoes changes in the progress of growth. This mucilaginous matter is the *Protoplasm* (πρῶτος, first, and πλάσμα, formative matter) of Mohl, the *Cytoblastema* (κύτος, a cell, and βλάστημα, a germ) of some authors. It is at first homogeneous, but ultimately assumes a granular form. The appearance of granules may be regarded as the earliest evidence of the formative process. It contains nitrogen in its composition, or is azotised, and it assumes a brownish colour when acted upon by iodine. It forms a mucilaginous layer on the inner surface of the cell-wall, and thus gives rise to the *internal utricle* of Harting and Mülder, the *primordial utricle* of Mirbel. This inner membrane is visible in the young state of the cell, and under the action of tincture of iodine may be made to contract and separate from the outer cell-wall. It may also be rendered distinct by the action of strong hydrochloric acid, and by diluted sulphuric acid. When the process of lignification or thickening has advanced, this utricle disappears, in consequence of becoming incorporated with the cell-wall.

15. In certain cells the membrane continues throughout to be formed of a thin layer of cellulose, while in others it becomes thickened by the deposition of matter on its inner side. These secondary deposits, or incrustations, are sometimes of a gelatinous consistence; at other times they are hard. In the latter case, the incrusting matter is looked upon as a modification of cellulose, and has received the name

Fig. 29.—Cellular tissue of Sea-weed (*Himanthalia lorea*). *a a*, Cells. *b*, Intercellular matter.
Fig. 30.—Central portion of young root of Date. *a a a*, Thickened cells. *b b b*, Intercellular substance of Mirbel.

of *lignine* (*lignum*, wood), or *sclerogen* (σκληρὸς, hard, and γεννάειν, to generate). On making sections of such cells, in a transverse (fig. 31) or longitudinal direction (fig. 32), the successive layers may be seen either continuous all round, or leaving parts of the membrane uncovered. Cells of this kind are well seen under the microscope in thin sections of the hard shell of the Coco-nut, or of Attalea funifera, and of the hard seed of the Ivory Palm. In all cell-deposits there is a tendency to a spiral arrangement. When the deposition is uniform over the whole surface, this arrangement may not be detected; but when interruptions take place, then the continued coil becomes evident. In spiral cells the fibre seems to be formed before the full development of the cell, the coils of the fibre being at first in contact, and afterwards separated, whereas the secondary thickening layers are deposited after the cell is fully formed. According to the observations of Barry, Agardh, and others, the filamentous origin of fibrous structures is recognizable in the earliest stage of cell growth, and the interweaving of these filaments constitutes the cell-walls.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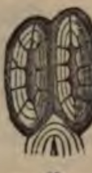
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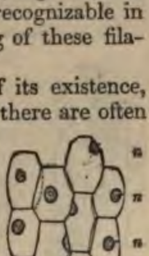
16. Each cell is found to contain at some period of its existence, a small body called a *nucleus* (fig. 33 *n n n*,) in which there are often one or two, rarely more, minute spots called *nucleoli*. The nucleus is of a round or oval shape, granular and dark, or homogeneous and transparent, bearing some resemblance to a smaller internal cell. Nucleoli are not always present. They are either vesicles and granules contained in the nucleus, or minute cavities in its substance. The latter view is supported by Barry, who holds that a peculiar substance called *hyaline* (ὕαλος, glass), is developed there, which, according to him, is the origin of the nucleus. The nucleus is situated at different parts of the cell. It is either free in its cavity, or connected with its walls by mucilaginous threads, or imbedded in the substance of the membrane. The addition of acetic acid often renders the nucleus distinct.



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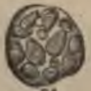
17. **Starchy matter** is found in cells, which constitute the tissue called by Morren, *Perenchyma* (πηρα, a sac.) Starch exists in the form of granules, which are minute cells, (perhaps nuclei, as Mülder states,) in which nutritious matter is stored up. This matter may be deposited in such a way as to give the appearance of striæ surrounding a point or hilum, which is considered as an opening into the cell. The grains of starch are well seen in the cells of the potato (fig. 34).

Fig. 31.—Transverse section of cells from pulp of Pear.
Fig. 32.—Longitudinal section of the same.
Fig. 33.—Nucleated cells from the Beet.

In wheat (fig. 35), and in maize (fig. 36), the form of the granules, and the successive layers of deposit, are also seen. The grains in the stem of Nuphar luteum show the centripetal formation, that is, the increase by layers deposited within each other. The addition of iodine causes the grains of starch to assume a blue colour, and marks the difference between them and the walls of the cell containing them. Schleiden affirms starch to be the most widely diffused substance in the vegetable kingdom; its presence may be regarded as in a measure indicating the age of the cell. With its formation in many cells, we have a limitation of vital activity, by which the organism is brought into such a condition that the power of germination may be preserved for a very long period.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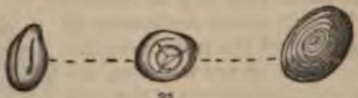
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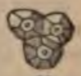
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18. **Crystals** are found in the interior of cells. They probably owe their origin to the union between the acids produced or taken up by plants, as oxalic, phosphoric, malic and carbonic, and the alkaline matter, as lime and potash, absorbed from the soil and circulating in the sap. The crystals usually lie loose in the cells (figs. 37, 38); but, according to Payen, they are sometimes found in a distinct tissue, and suspended from the wall of a large cell (fig. 39)—filling what some have supposed to be the base of an undeveloped hair. The crystals are of different sizes and forms. Occasionally, a single large crystal nearly fills a cell, but in general there are numerous crystals united together. Sometimes the crystals radiate from a common point (figs. 40, 41), and form a conglomerate mass; at other times they lie parallel, and have the appearance of bundles of fine needles (figs. 37, 38). To the latter, the name of *Raphides* (ῥαφὶς, a needle), or *acicular* crystals (*acus*, a needle), was originally given. It has been said that these crystals exist also in the intercellular spaces; but this seems to depend on the mode in which the section of the plant is made, for when raphidian cells (fig. 42 *r r r r*) are situated close to a lacuna, the crystals may easily be pushed into it accidentally by the knife. Raphides consist principally of phosphate and oxalate of lime. They abound in some plants, especially Cacti, and they are common in Squill, and in the

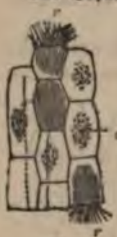

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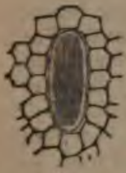
Fig. 34.—Cell of Potato, containing striated starch grains.
Fig. 35.—Grains of starch of Wheat. Fig. 36.—Grains of starch of Maize.
Fig. 37.—Cellular tissue of Arum maculatum. *c*, Cells containing chlorophylle. *r r*, Raphidian cells.

officinal Turkey Rhubarb, the latter of which owes its grittiness to their presence. One hundred grains of rhubarb root contain about 30 or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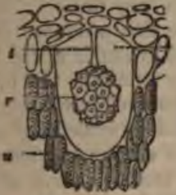

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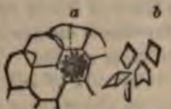

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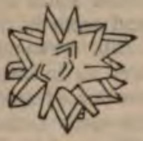
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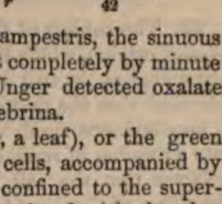
40 grains of oxalate of lime crystals. Acicular crystals may be easily seen by making a section of any Liliaceous plant, as the hyacinth, and spreading the thick mucilaginous matter of the cells on the field of the microscope. Radiating raphides are seen in the sepals of Geranium robertianum and lucidum; the crystals, consisting of oxalate of lime, fill the whole of the cells in the middle of the sepal, their size varying from $\frac{1}{2000}$ to $\frac{1}{1500}$ of an inch. Quekett found them in all the species of Pelargonium and Morisonia that he examined, and he thinks that they are as general as the beautiful markings in the cuticle of the petals of these plants. Clustered crystals have been detected in Malvaceous plants, and in the sepals of the strawberry; numerous acicular crystals have been observed in Fuchsias, and solitary cubical crystals in the superficial cells of the sepals of Prunella vulgaris and Dianthus Caryophyllus. In the outer covering of the seed of Ulmus campestris, the sinuous boundaries of the compressed cells are traced out completely by minute rectangular crystals adhering to each other. Unger detected oxalate of lime crystals in Ficus indica and Calathea zebrina.



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19. **Chlorophyll** (χλωϱὸς, green, and φύλλον, a leaf), or the green colouring matter of plants, floats in the fluid of cells, accompanied by starch grains. It differs from starch in being confined to the superficial parenchyma, and in being principally associated with the phenomena of active vegetable life. It has a granular form (fig. 39 *u*, 42 *c*), is soluble in alcohol, appears to be analogous to wax in its composition, and is developed under the agency of light. It is well seen in

Fig. 38.—Cells of Arum maculatum. Clusters of raphides in a large oval cell surrounded by smaller cells.

Fig. 39.—Cellular tissue, from leaf of Ficus elastica. *c*, A large cell. *r*, An agglomeration of crystals suspended in a sac by a tube, *t*. *u*, Utricles filled with grains of chlorophyll.

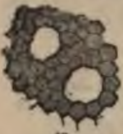
Fig. 40.—Cells of Beet with conglomerate radiating crystals, *a*. *b*, Separate crystals of different forms.

Fig. 41.—Conglomerate crystals of oxalate of lime from Rhubarb.

Fig. 42.—Cellular tissue of Colocasia odora. *c c*, Cells with grains of chlorophyll. *r r r r*, Raphidian cells projecting into a lacuna or intercellular space.

leaves. Under the influence of darkness it undergoes changes which are seen in the phenomenon of blanching or etiolation. Its granules are usually separate, but sometimes they unite in masses (fig. 37 *c*). Other kinds of colouring matter are also produced during vegetation, and occur in the form of fluids or of granules in the interior of cells.

20. **Oils** and **Resinous matter** are found in the interior of cells, as well as in intercellular spaces. The cavities containing them are denominated *cysts*, *reservoirs of oil*, and *receptacles of secretions*. They are easily detected in the rind of the orange and lemon, in the myrtle tribe, and in Hypericum. When small portions of the fresh leaf of Schinus Molle are thrown on water, the resinous matter, by its rapid escape, causes them to move by jerks, and the surface of the fluid is covered with the exudation. In the bark of the Fir tribe there are cavities with thick walls containing turpentine. In the fruit of Umbelliferæ, canals occur called *vittæ* (*vitta*, a head-band, from surrounding the fruit), containing oil.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21. **Air cells**, or cavities containing air, consist either of circumscribed spaces surrounded by cells (fig. 43), or of lacunæ formed by the rupture or disappearance of the septa between a number of contiguous cells, as in grasses, Equisetum, Umbelliferous plants, and pith of Walnut. They are often large in aquatic plants, and serve the purpose of floating them, as in Pontederia, Trapa, Aldrovanda, and sea-weeds. The air-cells of Limnocharis Plumieri are beautiful objects.

3.—Development and Functions of Cells.

22. The subject of *Cell-development*, or *Cytogenesis* (κύτος, a cell, and γένεσις, origin), which has given rise to great diversity of opinion among physiologists, is still involved in much obscurity. By some it is affirmed that the first appearance of vegetable tissue is in the form of a mucilaginous fluid, which, gradually thickening, becomes hollowed into a number of small cavities constituting the future cells. Schleiden believes that the cell is formed from the nucleus, to which he gave the name of *Cytoblast* (κύτος, a cell, and βλαστὸς, a germ), or *cell-germ*, from its supposed generative function. This cytoblast, according to him, is the part first formed. It acts by attracting the mucilaginous matter in which it lies, and forming around itself a sort of gelatinous covering. There is thus produced round the nucleus a closed utricle, which increases in size by the assimilation of the fluid in which it is placed. The development usually takes place on one side, the new cell appearing in the form of a transparent vesicle rising from the surface, and leaving the nucleus attached to the other side of the

Fig. 43.—Air-cells in Ranunculus aquatilis.

utricle (fig. 33). The cytoblast is thus enclosed in the utricle, and may ultimately disappear by absorption, leaving a non-nucleated cell. The membrane surrounding the nucleus is converted gradually into cellulose, and thus the perfect cell is formed. According to Mohl, the nucleus is at first retained in the centre of the cell by means of mucous threads, and afterwards becomes fixed to the sides. Occasionally, the nucleus becomes imbedded in a duplication of the cell-wall. This process of self-development, according to Ascherson, is similar to what takes place when oil is mingled with a mucilaginous or albuminous fluid, each minute molecule of oil becoming surrounded by a thin film of membrane. In this view the cell is originally of a more or less globular form, and all the varieties of shape afterwards seen are due to changes in the progress of growth.

Barry affirms that a minute pellucid globule (*hyaline*), is first seen in the formative matter. This absorbs and assimilates new matter, enlarges and becomes granular, thus forming the cytoblast of Schleiden, after it has prepared a nucleolus for itself. The outer part of the cytoblast rises in the form of a membrane to produce a cell; another portion of it is concerned in the formation of the contents of the cell; and what is left of the cytoblast in the cell-wall becomes the nucleus of the cell. This nucleus (not the cytoblast of Schleiden) remaining on the cell-wall, is not absorbed, but becomes the source whence cytoblasts are formed. Thus, according to Barry, the substance of the larger body is not deposited around the smaller, but the smaller is transformed into the larger; the nucleolus becomes the cytoblast, and the cytoblast becomes a nucleated cell.

As regards the development of cells from nuclei, the present state of our knowledge does not warrant us in stating more than that there is a protoplasm, or soft organizable matter, which is contained in cells, or in the spaces between them; that in this matter a nucleus is produced, either around previously existing nucleoli, or from the granules of the protoplasm; and that the nucleus has the power of developing new cells, which become nucleated, increase in size, and escape from the parent cell, by rupture or absorption. In the production of young cells, the nucleus of the parent cell sometimes divides into two, each part having the power of giving rise to a new cell. There is thus a constant multiplication of cells by an intra-cellular or endogenous (ἔνδον, within, and γεννάειν, to generate) process.

23. It is supposed by some that cells may arise without a nucleus, by the simple aggregation of granular matter, which becomes enveloped in a membrane, and thus forms a cell with granular contents. In such cells, a body similar to a nucleus may be afterwards formed, and may assume the function of the cytoblast of Schleiden, as far as the subsequent endogenous development of new cells is concerned. Some physiologists maintain that the cytoblast is never concerned in

cytogenesis, but only takes part in the various chemical and other changes which occur in the contents of the cell during its growth and nutrition. Mohl and Henfrey state that new cells are produced by the division of the primordial utricle (¶ 14), which gradually folds inwards about the middle, forming an annular constriction, and ultimately a complete separation of the utricle into two parts. Each of these afterwards becomes covered by a permanent cell-wall. Henfrey has supported this view by observations made on the hairs of Tradescantia and of Achimenes grandiflora, in which he has traced the gradual formation of a septum.

24. Naegeli maintains that new cells are produced by the division of the primordial utricle, or mucilaginous sac, as he calls it, and its contents into two or four portions, each of which encloses a free nucleus. From each of these portions, a cell, with its outer layer of cellulose, originates, while the parent cell becomes dissolved and disappears. The outer layer of the new cells is formed, according to him, round, and by the separate portion of the divided utricle. The mode of division he does not explain. This view does not appear to differ much from that adopted by Unger, who traces in Algæ the development of new cells, by a *fissiparous* (*fissus*, split, and *pario*, I produce), or *merismatic* (μερισμός, division) separation of the old ones into four divisions, in the same way as occurs in pollen grains. In some of the most simple plants, multiplication takes place by a sort of sprouting of new cells from old ones, like buds from a stalk.

25. The various theories of cell-development may be therefore reduced to the following: 1. The Endogenous formation, within a parent cell; 2. The Exogenous, without, or on the outside of the cell; 3. Merismatic, or by division of cells; 4. Isolated, or the independent formation of cells in a protoplasm. Cells are also formed by what has been called *Conjugation*, or by the union of two cells, which by their mutual action give origin to a third. This is particularly seen in some of the lower Algæ.[*]

26. The formation of cells from nuclei, and their fissiparous division, are by some attributed to different electrical currents excited by the chemical actions going on in the cell. Cells are produced with great rapidity, especially in the case of fungi. From an approximative calculation, it is found that in Bovista gigantea 20,000 new cells are formed every minute. Ward has noticed a similar occur-

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[*] For a full view of the subject of the development and growth of cells, the following works may be consulted:—Schleiden on Phytogenesis, and Mohl on the Structure of the Vegetable Cell, translated in Taylor's Scientific Memoirs, Vols. II. and IV.; Naegeli on Vegetable Cells, Ray Society's Reports, 1846; Sharpey, Anatomy; M. Barry, Physiology of Cells, &c., in Philosophical Transactions, 1840; and on Nucleus of Cells, in Jameson's New Philosophical Journal for September, 1847; Carpenter's Physiology; Braun on the Phenomenon of Rejuvenescence in Nature, Ray Society's Reports, 1853.

rence in Phallus impudicus. In warm climates, at the commencement of the wet season, the production of cells in the higher classes of plants proceeds with astonishing rapidity.

27. The organized cells of plants appear to be the more immediate seats of the various changes which constitute the functions of nutrition and reproduction. In cellular plants they are the only form of elementary tissue produced throughout the whole of life. They absorb nourishment through their walls, elaborate secretions, and give rise to new individuals. In the newly-formed tissue of vascular plants, cells alone at first exist. Fluid matters are absorbed by them, and are transmitted from cell to cell by a process of transudation. The name of Endosmose (ἔνδον, inwards, μάω, μῶ, I seek), and Exosmose (ἔξω, outwards), were given by Dutrochet to the process of transudation, which leads to the motions of fluids of different densities placed on opposite sides of animal and vegetable membranes. This process appears to be of universal occurrence in plants, being concerned in the movements of the sap, the opening of seed-vessels, and many other phenomena. The capsule of the Elaterium, for instance, opens with great force by a process of endosmose going on in the cells, and such is also the case with that of the Balsam. The power which cells possess of absorbing fluids is well seen in sea-weeds, which, after being dried can easily be made to assume their natural appearance by immersion in fluids. It is also observable in the spores of the Equisetum, the teeth of Mosses, the seed-vessels of some Fig-marigolds, the Rose of Jericho (Anastatica), and some Lycopodiums.

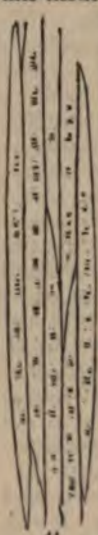
Various organic secretions, which are necessary for growth and nourishment, are formed by the internal membrane of cells. It is in cells that the azotised and unazotised matters are deposited, which are afterwards applied to the purposes of vegetable life. In them we meet with the proteine compounds, albumen, fibrine, and caseine, consisting of carbon, oxygen, hydrogen, and nitrogen, with proportions of sulphur and phosphorus; as well as starch, gum, sugar, oil, and colouring matters, in which no nitrogen occurs. Some of the organic matters found in plants have been artificially formed by chemical means, while others have only as yet been met with in the living organism. Spiral cells sometimes contain air.

SECTION II.—VASCULAR TISSUE.

1.—FORM AND ARRANGEMENT OF VESSELS.

28. **Vascular tissue**, or *Angienchyma* (ἄγγος, a vessel), consists of tubes, whose length greatly exceeds their breadth. These may be formed of membrane only, or of membrane altered in various ways by deposits of fibre, or thickening matter in the interior.

29. **Woody Fibre**, or **Ligneous Tissue**, *Pleurenchyma* (πλευρά, a rib, from its firmness), (fig. 44,) consists of tubes, or, according to some, elongated cells, of a fusiform (*fusus*, a spindle) or spindle-like shape (fig. 3), having their walls thickened so as to give great firmness. This form of tissue does not exist in cellular plants. Some have called this tissue *Prosenchyma* (πρός, close to, in reference to the close apposition of the tubes), a term, however, generally applied to shortened fusiform cells only. Pleurenchymatous vessels lie close together, overlap each other, and, by their union, give strength and solidity to the plant. Their membrane becomes thickened by successive deposits of layers of cellulose and sclerogen, and in a transverse section the tubes present the appearance of concentric circles, occasionally with intervals, where the ligneous matter is deficient (fig. 45). The wood of trees is made up of fibres or tubes of this kind, and they are found in the inner bark, and in the veins of leaves. The woody fibres may be separated from the cellular parts of plants by maceration. In this way Flax and Hemp are procured, as well as the Bast used for mats. The strength of the woody fibres of different plants varies. Thus, New Zealand Flax, the produce of Phormium tenax, is superior in tenacity to Common Hemp; while the latter, in its turn, excels Common Flax, as well as Pita Flax, which is the produce of Agave americana. Linen is formed from woody tissue. Cotton, on the other hand, consists of elongated cells or hairs, the membrane of which becomes contracted in the process of drying, so as to appear twisted when viewed under the microscope. By this character mummy cloth was shown to be composed of linen. Woody fibres, in fabric, form muslin, lace, &c., (some fine Indian muslins only are formed from woody fibre; other muslins are made of cotton;) when reduced to small fragments, they constitute the pulp whence paper is made.



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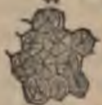

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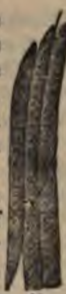
30. In its ordinary form, Pleurenchyma has no definite markings on its walls; but in some instances these present themselves in the form of simple discs (fig. 46), or of discs with smaller circles in the centre (fig. 47.) The latter occurs in the wood of Firs, Pines, and Winter's bark, and has received the name of *glandular* or *punctated* woody tissue. These markings are formed by concave depressions on the outside of the walls of contiguous tubes, which are closely applied to each other, forming lenticular cavities between the vessels, like two watch-glasses in apposition, and when viewed by transmitted light they appear like discs (fig. 46.) In the centre of the depression

Fig. 44.—Woody fibres (*Pleurenchyma*), from Clematis Vitalba.
Fig. 45.—Transverse section of the same.

there is a canal, often funnel-shaped, and the part of the tube corresponding to it being thus thinner than the surrounding texture, gives the aspect of a smaller circle in the centre (fig. 47). When a thin section is made through two parallel lines of punctations, the slits or fissures are seen which give rise to the appearances mentioned (fig. 48). That these markings are cavities between the fibres was proved by Quekett in the case of fossil pine wood, where he separated lenticular masses of solid matter from the discs. There is sometimes observed a thickening layer, in the form of a spiral fibre, surrounding the discs more or less completely. The discs are usually arranged in single rows, but they occur also in double and triple rows, more particularly in Araucaria and Altingia,—the markings alternating with each other.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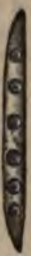
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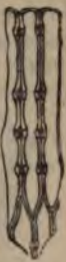
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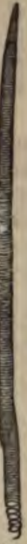
31. **Fibro-Vascular Tissue,** or *Trachenchyma* (*trachea*, windpipe; τραχὺς, rough), is formed of membranous tubes tapering at each end, less firm than Pleurenchyma, and either having a fibre coiled up spirally in their interior, or having the membrane marked with rings, bars, or dots, arranged in a more or less spiral form.

32. **True Spiral Vessels,** *(spiroidea, tracheæ)*, constituting the typical form, present themselves as elongated tubes clustered together, overlapping each other at their conical extremities, and having a spiral fibre or fibres surrounding the interior of the cylinder (fig. 49). Their outer membrane is thin, and consists of pure cellulose. At the point where they overlap, it is sometimes absorbed, so as to allow direct communication between the vessels. The fibre or spiral filament is generally single, forming *simple tracheæ* (fig. 50); but sometimes numerous fibres, varying from two to more than twenty, are united together, assuming the aspect af a broad ribband (fig. 51), and constituting *Pleiotracheæ* (πλείων, more). The fibre is elastic, and can be unrolled. This can be seen by taking the leaf of a Pelargonium, and after making a superficial cut round the stalk, pulling the parts gently asunder, when the fibres will appear like the threads of a cobweb.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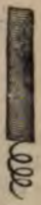
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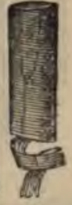
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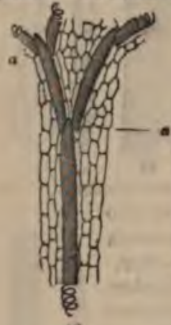
33. Spiral vessels were first noticed as early as 1661, by Henshaw

Fig. 46.—Woody fibres with circular spots where the membrane is thin (*Bignonia*).
Fig. 47.—Punctated woody tissue, with double circles or discs, from common Scotch fir.
Fig. 48.—Longitudinal section of the same, showing the union between the fibres and the mode in which the circles are formed.
Fig. 49.—Two spiral vessels united.
Fig. 50.—Simple trachea.
Fig. 51.—Spiral vessel with a ribband of united fibres *(Pleiotrachea)* from the Banana.

They occur principally in the higher classes of plants, and are well seen in annual shoots, as in Asparagus; in the stems of Bananas and Plantains, where the fibres may be pulled out in handfuls, and used as tinder; in many aquatics, as Nelumbium and Nymphæa; and in Liliaceous plants. In hard woody stems, they are principally found in the sheath surrounding the pith, and they are traced from it into the leaves. They are rarely found in the wood, bark, or pith. Spiral vessels occasionally exhibit a branched appearance. This may arise from the union of separate vessels in an angular or jointed manner, as where a leaf or branch is given off (fig. 52 *a a*), or it may depend on a regular division of the fibres, as is seen in the Mistleto, Long-leek, and Gourd (fig. 53).



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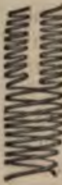

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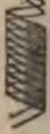
34. The fibre is on the inside of the membrane. Quekett has shown this in silicified spiral vessels, where the mark of the spiral was on the outside of the mineral matter filling the tube. The fibre usually turns from left to right, if we suppose the observer placed in the axis of the tube (fig. 54), or from right to left, if we suppose him looking at the vessel in its natural position. The fibre retains its direction throughout the length of the vessel. When examined under the microscope, there is often the appearance of the crossing of fibres (fig. 54), in consequence of the transparency of the membrane, and the observer seeing the fibre on each side of the vessel at the same time. In twining plants, the direction of the fibre does not always correspond with that of the stem. The coils of the spiral fibre may be close together (fig. 50), or be separated (fig. 55). Sometimes they become united together, and to the membrane of the tube, so that they cannot be unrolled. Such vessels are called *closed* tracheæ, or *closed* ducts, and are seen in ferns.



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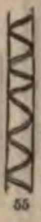

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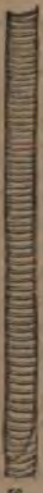
35. **False or Spurious Tracheæ,** the *ducts* of some authors, are vessels in which the internal fibre does not form a complete spiral coil. The chief varieties are *annular*, *reticulated*, and *scalariform* vessels, or ducts. In annular vessels (*annulus*, a ring), the fibres form complete rings round the tubes (fig. 56). They resemble the tracheæ of animals more than spiral vessels do. The rings are by no means regular; they may be horizontal or inclined, simple, or forked (fig. 57), placed near to each other or separated by considerable intervals, the inter-

Fig 52.—Spiral vessels, united so as to have a branched appearance.
Fig. 53.—Branching fibre, from spiral vessels of Gourd (*Cucurbita Pepo)*.
Fig. 54.—Spiral vessels. Coils seen on both sides.
Fig. 55.—Coils of fibre, much separated in trachea of Gourd.

mediate spaces being sometimes occupied by a fibre of an elongated spiral form, which is continuous with the rings or distinct from them (fig. 58). All these forms are easily recognized in the common Balsam. Occasionally, the ring becomes very much thickened in a direction perpendicular to the walls of the vessel, so as to leave only a small space in the centre, as in some of the Cactus tribe. When separate fibres cross each other, forming a kind of net-work on the walls of the tubes (fig. 59), the vessels become *reticulated* (*reticulum*, a net); and the name *dotted* is sometimes applied when the fibre is so broken up as to leave small isolated portions adhering to the membrane (fig. 60). In scalariform vessels (*scala*, a ladder), there are short horizontal lines or bars, composed of fibre, arranged along the sides of the tubes, at nearly equal distances, like the steps of a ladder, and presenting a striated appearance. In some cases, as in the Vine (fig. 61), they are composed of tubes united to each other by thin, broad, oblique extremities; at other times they taper like spiral vessels. They generally assume a prismatic form, the angles being unmarked by lines, as is seen in Ferns (fig. 62).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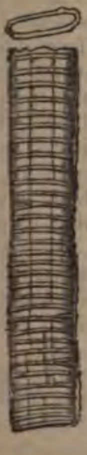
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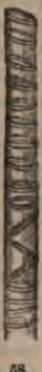
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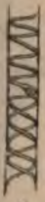
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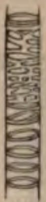
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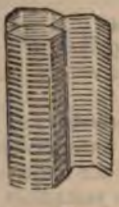
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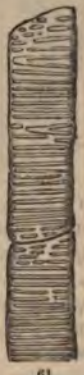
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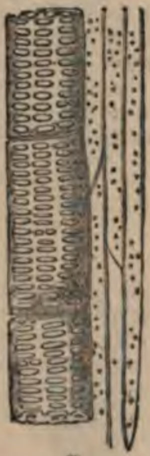
36. **Porous Vessels.**—Another kind of vessel common in plants is the *porous* vessel, so called from the appearance of pores on its surface.

Figs. 56, 57, 58.—Annular vessels from the stem of the Common Balsam.
Fig. 59.—Spiral vessel. Wide coil, and fibre dividing.
Fig. 60.—Vessel showing rings of fibre and dots.
Fig. 61.—Scalariform vessel from the Vine.
Fig. 62.—Prismatic scalariform vessel from Royal Fern (*Osmunda regalis*).

The tissue formed by porous vessels has received the name of *Vasiform tissue*, *Pitted tissue*, *Bothrenchyma*, or *Taphrenchyma* (βόθρος or τάφρος, a pit). The vessels are of large size, and are easily observed in the Vine (fig. 63), Sugar Cane, Bamboo, Gourd (fig. 98 *ter*), and other plants, in which the sap circulates rapidly They consist of cylinders more or less elongated, in which the thickening matter is so deposited as to leave part of the membrane uncovered, thus giving rise to the porous or pitted appearance. The uncovered portions of membrane are sometimes absorbed in old vessels, and a direct communication is established between them. The pores have sometimes a bordered aspect, which, according to Schleiden, depends on air contained in the cavities between contiguous vessels. Porous vessels are usually united to each other by a broad and often oblique septum.



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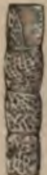

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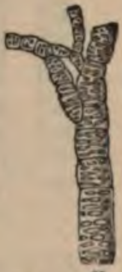

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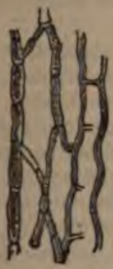
37. This kind of vessel occasionally presents a beaded appearance, as if formed by porous cells, with distinct constrictions at their point of union (figs. 64, 65). This articulated Bothrenchyma is by some considered as a form of cellular tissue (¶ 10, fig. 22). To vessels exhibiting contractions of this kind, whether spiral or porous, the terms *moniliform* (*monile*, a necklace), or *vermiform* (*vermis*, a worm), have been applied; and the tissue composed of spiral, annular, or porous moniliform vessels, has been denominated *phleboidal* (φλέψ, φλεβός, a vein).

38. **Laticiferous vessels** form the tissue called *Cinenchyma* (κινέω, I move, from certain movements of their contents, to be afterwards noticed). They are the Milk-vessels, and the Proper vessels of old authors; and of late years they have been particularly examined and described by Schultz. They consist of long, branched, homogeneous tubes, having a diameter of about $\frac{1}{1400}$ of an inch, which unite or anastomose freely (fig. 66), thus resembling the vessels of animals. At first the tubes are very slender and uniformly cylindrical (fig. 67 *a*), but afterwards they enlarge and present irregular distensions at different parts of their course (figs. 67 *b*, 68), so as to give rise to an articulated appearance. Their walls vary in thickness, and are not

Fig. 63.—Porous vessel (*Bothrenchyma*) from the Vine, showing its connection with woody fibres, and the broad septa or partitions of the vessel itself.
Fig. 64.—Porous vessel from Traveller's joy (*Clematis Vitalba*).
Fig. 65.—Moniliform porous vessels from the Common Balsam.

marked by any depressions or fibres. These vessels are met with in the inner bark, and they contain a granular fluid called *latex*, which is at first transparent, but often becomes of a white, yellow, or reddish colour. Endlicher and Unger state that they are formed by cells united in a linear series, their septa being obliterated; while Meyen and Schleiden maintain, that at a very early period the currents of latex may be seen in the intercellular canals, and that ultimately a separate membrance is developed to form the vessels. The tissue can be easily examined in the India-rubber tree, in Dandelion, Lettuce, and Celandine, and in various species of Ficus and Euphorbia.



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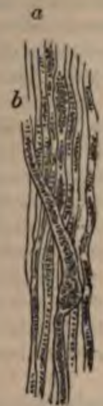

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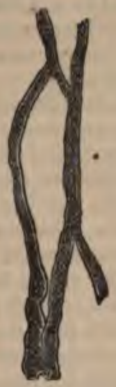

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2.—Development and Functions of Vessels.

39. The simple cell is the state in which vegetable tissue first makes its appearance. It is the primary form of all the textures subsequently produced in vascular plants. To the elongation of cells, and the deposition of thickening layers and fibres in their interior, the various vessels owe their origin. Thus when cells are developed as continuous branching tubes, which anastomose freely, Cinenchyma is formed; when they are elongated, as spindle-shaped tubes, and their walls are thickened and hardened by depositions of ligneous matter, they give rise to Pleurenchyma; and when elongated membranous tubes are strengthened by spiral fibres, the different kinds of Fibro-vascular tissue are produced. The spiral vessel may be considered as the type of the last-mentioned tissue, and all its varieties may be traced to changes

Fig. 66.—Laticiferous vessels (*Cinenchyma*) from Euphorbia dulcis.
Figs. 67, 68.—Vessels of Latex from Celandine (*Chelidonium majus*).

taking place in the development of the fibre. The coil may be broken in consequence of the fibre adhering to the membrane, and the latter increasing rapidly in growth; or the fibre may be deposited irregularly, in consequence of interruptions in growth. This view of the formation of vessels is confirmed by finding in the same tube a complete spiral fibre in one part, annular fibres, either complete or with their ends overlapping, at another, and bars or dots at a third portion. In the case of some vessels, their formation can be distinctly traced to cells placed end to end, the partitions between which have been absorbed. The moniliform or beaded appearance often presented by the different kinds of vessels, more especially the Porous, plainly indicates this mode of formation.

40. As in cells, so in vessels, the walls are composed of cellulose, and there are usually no visible perforations; the communication between them taking place by imbibition or endosmose. In some instances, when vessels are closely applied to each other, especially when they overlap, the membrane becomes absorbed, and direct communication takes place. This has been seen in spiral and porous vessels. The pits or depressions on the walls of vessels, and the thinning of the tissue at particular points, appear to serve the purpose of allowing the rapid transmission of fluids; and, according to some, they permit the passage of small cells from the interior, which become developed as tubes, and form branching vessels.

41. Pleurenchyma, in its early state, contains fluids, and conveys them from one part of the plant to another. In the progress of growth, the secondary deposits obliterate the vessels, as in the perfect or heart wood of ordinary trees. These deposits are often of a very hard nature, and assume particular colours in different kinds of trees. From the firmness of this tissue, it is well fitted to give solidity to the stems and to strengthen the leaves of plants. In Spiral vessels, the fibre adds to their elasticity, and keeps the tubes always pervious. The fibre, when once formed, does not increase much in thickness, and the secondary deposits do not obliterate the canal. Various opinions have prevailed regarding the contents of these vessels. The name *Tracheæ*, given by Grew and others, was partly from their structure, and partly from the idea that they contained air. The accurate experiments of Bischoff lead to the conclusion that the perfect spiral vessels convey air, which often contains a large amount of oxygen in its composition. Hales showed that air was evolved from the vessels of the Vine when cut, and Decandolle thought that part of the air in these vessels was derived from the pores of the leaves. Other authors look upon these vessels as conveying fluids, while a third set maintain hat both air and fluids are present, the air being derived in part from compositions going on in the interior of the plant. The other kinds vascular tissue, and especially the porous vessels, are the means

by which the fluids taken up by the roots of plants are conveyed to the leaves, and to all parts of the plants. Laticiferous vessels contain, according to Schultz, the elaborated sap or latex on its return from the leaves to the bark. This latex is either transparent or opaque, colourless or coloured. These vessels, when examined with the microscope in the living plant, exhibit movements in their fluid contents of a peculiar kind, which will be considered under *Cyclosis*. (p. 134)

42. The cell has been already shown to be the type of all the tissues of plants, and to be the basis of all vegetable structure. It is of equal importance as regards function. In the lowest plants, as the Protococcus nivalis, or the Alga found in red snow, and the various species of Palmella, Nostoc, and Hæmatococcus, cells constitute the whole substance, and perform all the functions of life; they absorb and assimilate, thus performing the functions of nutrition and secretion, and they form new cells, thus reproducing individuals like themselves. When a more complex structure exists, as in the higher tribes of plants, certain cells are appropriated for absorption, others are concerned in assimilation, and others in forming and receiving secretions. When a certain degree of solidity appears to be required to support the stem, leaves, and flowers, ligneous matter is deposited, and woody fibre formed. When the transmission of fluids and air is carried on rapidly, the elastic fibres of the fibro-vascular tissue seem to keep the elongated cells and vessels pervious, and when the elaborated sap is conveyed continuously without interruption, anastomosing tubes occur in the form of laticiferous vessels.

TABULAR ARRANGEMENT OF VEGETABLE TISSUES.

A.—Cellular Tissue (Parenchyma), composed of membrane, or of membrane and fibre, having the form of vesicles whose length does not greatly exceed their breadth.

1. Membranous Cellular Tissue; cells formed by membrane alone, of various thickness, but without markings on it.

2. Porous Cellular Tissue; cells formed by membrane, which has been unequally thickened in such a way as to leave rounded depressions at regular intervals.

3. Fibrous Cellular Tissue (Inenchyma); cells formed by membrane and fibre; occasionally formed by fibre alone.

a. Spiral Cells, with a complete spiral fibre inside.

b. Dotted Cells, with opaque spots, which are isolated portions of fibre.

B.—Vascular or Tubular Tissue (Angienchyma), composed of cylindrical tubes, which are more or less continuous, and usually overlap each other, or are united by broad oblique extremities.

I. Membranous Vascular Tissue; tubes formed by membrane alone, of various thickness, but without markings on it.

1. Ligneous Tissue (Pleurenchyma), composed of fusiform tubes with thickened walls.

2. Laticiferous Tissue (Cinenchyma), composed of tubes which anastomose, often present irregular dilatations, and convey a peculiar fluid, called Latex.

- II. Porous Vascular Tissue; tubes formed by membrane, which becomes thickened by spiral deposits, in such a way as to leave rounded depressions at regular intervals.
  - 1. Vasiform Tissue, or Porous vessels (Bothrenchyma or Taphrenchyma); large tubes, usually ending in broad extremities, with pits or circular markings on their walls. This tissue sometimes exhibits contractions at regular intervals, as if formed of porous cells laid end to end, and then is called Moniliform, or Beaded (Articulated Bothrenchyma).
  - 2. Punctated Tissue (Glandular Woody Tissue); fusiform woody tubes, with depressions and markings on their walls, presenting the appearance either of a single or double circular disc.
- III. Fibro-Vascular Tissue, composed of tubes in which the thickening matter is deposited in the form of spiral fibres, rings, bars, or dots.
  - *a.* Perfect Fibro-Vascular Tissue, composed of tubes, in which there is a complete spiral fibre.
    - 1. Spiral Vessels (Tracheæ, Trachenchyma), in which the spiral fibre is elastic, and may be unrolled.
    - 2. Closed Spiral vessels, or closed Tracheæ, in which the spiral fibre is brittle, or its coils so united to each other, and to the membrane, that they cannot be unrolled.
  - *b.* Imperfect Fibro-Vascular Tissue, composed of tubes marked by rings, lines, or dots, but without a complete fibre inside.
    - 1. Annular Vessels or Ducts, having fibres in the form of detached rings, which are occasionally united by portions of fibre.
    - 2. Reticulated Vessels, having fibres which cross each other, or are disposed so irregularly as to form a net-work.
    - 3. Scalariform Vessels, having their walls marked by isolated portions of fibre, in the form of ladder-like bars.
    - 4. Dotted Vessels, having their walls marked by isolated portions of fibre in the form of opaque dots or points.

Any of the vessels included under the Fibro-vascular tissue, may exhibit contractions at regular intervals, so as to become moniliform.

CHAPTER II.

COMPOUND ORGANS FORMED BY THE TISSUES.

43. Some plants consist of cells only, which continue throughout life to produce new cells, and to perform all the vital functions. The great mass of flowering plants, however, although originally cellular, produce organs composed of cells and vessels variously arranged, and covered by an epidermis. These compound Organs may be divided into *Nutritive*, or those concerned in the nourishment of the plant; and *Reproductive*, or those which are employed in the production of new individuals. The former consist of the stem, root, and leaves; the latter, of the flower and fruit.

SECTION I.—ORGANS OF NUTRITION OR VEGETATION.

1.—Structure, Arrangement, and Special Functions.

44. Under this head will be considered the tissues of which the various nutritive organs are composed, the mode in which the parts are arranged, and the particular function which each of the organs performs.

GENERAL INTEGUMENT.

45. **General Integument** is the name given to the external cellular covering of plants. It can be easily detached from young leaves and stems, usually in the form of a colourless transparent membrane. By prolonged maceration it has been shown to consist frequently of two layers; a superficial, called *Cuticle* or *Pellicle* (fig. 69 *p p*), and a deep layer, usually called the *Epidermis* (fig. 69 *e e*).

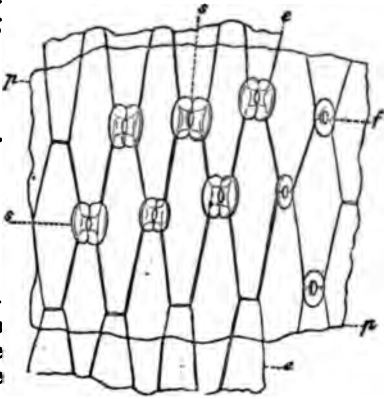

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Fig. 69.—General integument of a leaf of Iris germanica. *p p*, The Cuticular pellicle with slits, *f*, lying upon the proper epidermis, *e e*, formed of hexagonal cells, and furnished with stomata, *s s*.

46. **The Superficial Pellicle** (*pellis*, skin) is a very thin continuous membrane, which is spread over all parts except the openings of the stomata; in some cases entering these openings, and lining the cavities beneath them. It is formed from the epidermal cells below it; Treviranus, Schleiden, and Payen, considering it as a secretion on the outside of the cells, while Mohl and Henfrey look upon it as composed of the altered primary walls of the cells. Mitscherlich regards it as a corky substance which preserves the humidity of the plant, by preventing the evaporation of moisture. This substance is considered by him to be an important constituent of the cell-wall. In fig. 70 the pellicle is represented as detached from the leaf of the cabbage, forming a sheath over the hairs, *h h h h*, and leaving slits, *s s*, corresponding to the openings of the stomata. The pellicle is perhaps similar to the intercellular substance surround-

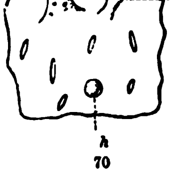

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Fig. 70.—Pellicle of Cabbage, detached by maceration, covering the hairs, *h h h h*, and having openings, *s s*, corresponding to the stomata.

ing cells, and to the *definite mucus* which is conspicuous in some seaweeds (fig. 29 *b*). It is possible that this matter, in place of being produced on the outside of cells, may be formed within them, and ultimately deposited externally by passing through their parietes. On the inner surface of the pellicle the impressions of the epidermal cells are sometimes observed (fig 69 *p*). The pellicle is the only layer of integument which is present in aquatic plants, and in some of the lower tribes.

47. **The Epidermis** (ἐπὶ, upon, and δέρμα, skin), (fig. 69 *e e*), is extended over all the parts of plants exposed to the air, except the stigma. The internal cavities of seed-bearing organs are lined by a delicate membrane, termed *Epithelium*. On the extremities of newly-formed roots, the integument consists of loose cells, which are considered either as being the ordinary cellular tissue of the plant, or as being an imperfectly-formed epidermis, which has received the name of *Epiblema* (ἐπὶ, upon, and βλῆμα, wound, as being the tissue which first covers wounds). This latter kind of tissue occupies the place of the epidermis, in the parts of plants which are always under water. On the aerial roots of Orchidaceous plants, there is an epidermal layer consisting of spiral cells (fig. 23), containing air.

48. The epidermis is usually formed by a layer or layers of compressed cells, which assume a more or less flattened tabular shape, and have their walls bounded by straight or by flexuous lines. Fig. 69 *e e*, represents an epidermis formed of regular hexagonal cells; fig. 72, one composed of irregular hexagons; while in fig. 71, the boundaries of the cells, *e*, are flexuous and wavy. The cells of the epidermis are so intimately united together, as to leave no intercellular spaces (fig. 74 *e e*).

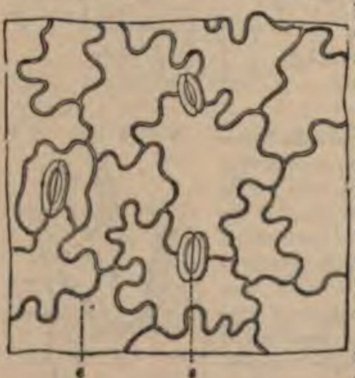

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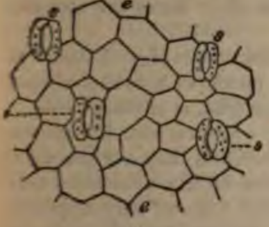
Fig. 71.—Epidermis, from lower surface of the leaf of Madder (*Rubia tinctorum*). *e*, Cell of the Epidermis. *s*, Stoma.

49. The epidermis is sometimes thin and soft, at other times dense and hard. In the former case it may be easily detached from the subjacent cells; in the latter, the cells become thickened by deposits, and sometimes the layers are so produced as to leave uncovered spots, which communicate with the interior of the cell by canals passing through the thickening layers, as in Cycas. In Rochea falcata (fig. 73), the epidermis, *e e*, consists of two layers of cells—the outer ones

large, the inner small. The cells of epidermis are usually filled with colourless fluid, but they sometimes contain resinous and other substances. Waxy matter is occasionally found in the epidermis, silica is met with in the integument of grasses and Equisetums, and carbonate of lime in that of Chara. The colour of the epidermis generally depends on that of the subjacent parenchymatous cells, from which it can be separated as a colourless layer. The epidermal cells are usually larger than those of the tissue below them; but sometimes, for instance in Ficus elastica, they are smaller.



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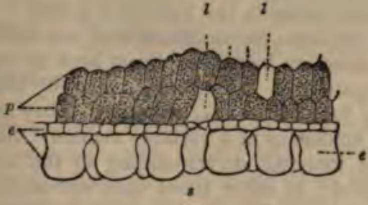

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50. **Stomata** (στόμα, a mouth) are openings existing between some of the cells of the epidermis on parts exposed to the air. They consist usually of two semilunar cells surrounding an oval slit or orifice (figs. 69 *s s*, 71 *s*), which have been considered as resembling the lips and the orifice of the mouth. Stomata open or close according to the state of moisture or dryness in the atmosphere,—these changes depending on the hygroscopic character of the cells. By examining, under the microscope, thin strips of epidermis in a moist and dry state, it will be seen that in the former case the lips are distended, they assume a crescentic or arched form, and leave a marked opening between them; while in the latter they collapse, approach each other, and close the orifice.

51. The cells surrounding the openings of stomata are sometimes numerous, as in Marchantia. In Ceratopteris thalictroides, Allman observed stomata formed by three cells; two of which, in their open condition, are crescentic and concave inside, while the third surrounds them, except at a small space at the end of the long axis of the stoma, and has on this account been called *peristomatic* (περὶ, around). In Equisetum, the stomata, which are about $\frac{1}{250}$ of an inch in their greatest diameter, consist of four pieces; two of which are

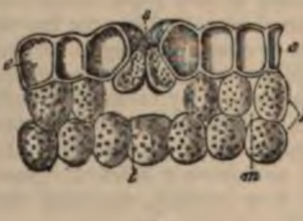
Fig. 72.—Epidermal layer, from upper surface of a leaf of *Ranunculus aquatilis* when growing out of water. *e e*, Epidermal cells. *s s s s*, Stomata.

Fig. 73.—Vertical section of lower epidermis of the leaf of *Rochea falcata*. *e e*, Double epidermal layer, with very large external cells, small internal ones, pierced by a stoma, *s*, which communicates with a lacuna, *l*. *p*, Parenchyma of the leaf.

arched and thick at their outer convex margin, becoming thin at their inner concave edge, where two other bodies occur, having numerous processes like the teeth of a comb, hence called *pectinate* (*pecten*, a comb). Occasionally the stomatic cells become united, so as to appear in the form of an uninterrupted rim; and at other times the stoma is a minute orifice in the walls of a cavity.

52. Stomata communicate with intercellular spaces (figs. 73 *s*, 74 *s*), the connection being sometimes kept up by means of a funnel-shaped prolongation of the cuticle, called, by Gasparrini, a *cistoma* (κίστη, a cyst or bag, and στόμα, a mouth). They are scattered over the surface of the epidermis in a variable manner. Sometimes they are placed at regular intervals corresponding to the union of the epidermal cells (fig. 69 *s*); at other times they are scattered without any apparent order (figs. 71, 72); and in other instances they are united in sets of two or three, or in clusters at particular points, as may be seen in Begonia, Saxifraga (fig. 75 *s s*), and Proteaceæ.

53. Stomata occur on the green parts of plants, especially on the leaves and their appendages. They are not usually found in cellular plants, nor in plants always submerged, nor in pale parasites. This is not, however, a universal rule, for stomata have been detected in Marchantia and some other *Cellulares;* also in the submerged leaves of Eriocaulon setaceum, according to Griffith, and in the pale parasite Orobanche Eryngii, according to Duchartre. They do not exist in roots, nor in plants kept long in darkness so as to be blanched or etiolated, and they are rare or imperfectly developed in succulent plants.



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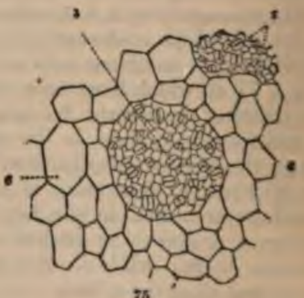

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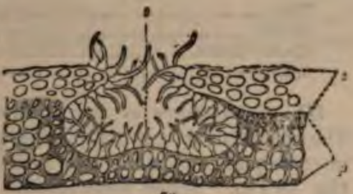
Fig. 74.—Vertical section of epidermis, from the lower surface of the leaf of Madder, showing the intimate union of the epidermal cells, *e e*, the loose subjacent parenchyma, *p*, with intercellular canals, *m*, and lacuna, *l*. *s*, Stoma.

Fig. 75.—Epidermis of leaf of Saxifraga sarmentosa, showing clusters of stomata, *s s*, surrounded by large epidermal cells, *e e*. The cells among which the stomata occur are very small.



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54. Stomata vary in their form. The oval form is very common, and may be easily seen in Liliaceous plants; the spherical occurs in Oncidium altissimum and the Primrose, the quadrangular in Yucca and Agave. In the Oleander, in place of stomata, there are cavities in the epidermis protected by hairs (fig. 76 *s*).

55. The development of stomata has been traced by Mirbel and Mohl. In the Hyacinthus orientalis, they appear first between the epidermal cells in the form of quadrangular spaces containing granular matter, which gradually collects towards the centre, where a septum or partition is formed. This septum ultimately splits, leaving a slit or opening which constitutes the stoma. Mohl has traced this process throughout the same leaf in different stages of growth. In Marchantia, Mirbel found several tiers of cells forming the stoma, and he supposed that the opening was produced by the absorption of a central cell, leaving the others to form the rim or border.

56. The number of stomata varies in different parts of plants. They are most abundant on the under surface of leaves exposed to the air, and are often entirely wanting on the upper surface, more especially when it has a dense shining cuticle. In floating leaves the stomata, when present, are on the upper surface only. When plants usually under water are made to grow for some time in the air, their leaves exhibit stomata. When leaves grow vertically, the stomata are often equal in number on both sides. The number of stomata varies from a few hundreds to many thousands on a surface of one inch square. The following table exhibits the number of stomata in the leaves of a few plants:—

STOMATA IN ONE INCH SQUARE.

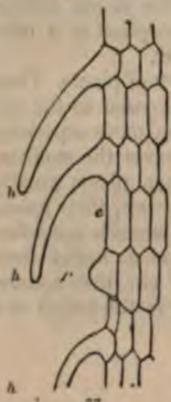
	Upper side.	Under side.
Mistleto,	200	200
Tradescantia,	2,000	2,000
Rheum palmatum,	1,000	40,000
Crinum amabile,	20,000	20,000
Aloe,	25,000	20,000
Clove-pink,	38,500	38,500
Yucca,	40,000	40,000
Mezereon,	None.	4,000
Pæony,	None.	13,000

Fig. 76.—Vertical section of lower epidermis of the leaf of *Nerium Oleander*. *e*, Epidermis composed of several layers of cells. *p*, Parenchyma of the leaf. *s*, Cavity filled with hairs which may represent a stoma.

	Upper side.	Under side.
Vine,	None.	13,600
Holly,	None.	63,600
Cherry-laurel,	None.	90,000
Lilac,	Few.	160,000

57. **Appendages of the Epidermis,** or **Appendicular Organs.**—The epidermis frequently exhibits projections or papillæ on its surface, in consequence of some cells being enlarged in an outward direction (fig. 73 *e e*). When these assume an elongated or conical form they constitute *hairs (pili* or *villi)*, as seen in (fig. 77 *h h h*).

Hairs, then, are composed of one or more transparent delicate cells proceeding from the epidermis, and covered with the cuticle (fig. 70). They are erect (fig. 78 *a*), or oblique, or they lie parallel to the surface, and are appressed. Sometimes they are formed of a single cell, which is simple and undivided (fig. 78 *a*), or forked (fig. 78 *b*), or branched (fig. 78 *c*); at other times they are composed of many cells either placed end to end, as in moniliform or neck-lace-like hairs (fig. 79), or united together laterally, and gradually forming a cone, as in compound hairs (fig. 80), or branched (fig. 81). When several hairs proceed from a common centre, they become stellate (*stella*, a star), or radiated (fig. 82). The latter arrangement occurs in the hairs of the Mallow tribe, and is well seen in those of Deutzia scabra. When stellate hairs are placed closely together, so as to form a sort of mem-



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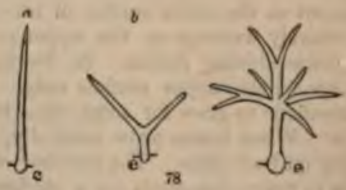

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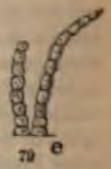

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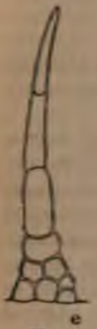
Fig. 77.—Young root of Madder, showing cellular processes, *h h h*, equivalent to hairs. *e*, The epidermal cells which are not elongated.

Fig. 78.—Hairs formed by single cells of the epidermis, *e*. *a*, Simple hair. *b*, Bifurcated hair of Sisymbrium Sophia. *c*, Branched hair of Arabis alpina.

Figs. 79—82.—Compound hairs formed by the union of several cells. *e*, Epidermis. 79. Moniliform hair, from Lychnis chalcedonica.

branous expansion (fig. 83), a *scale* or *scurf* is produced. To such expansions of the epidermis the name *lepis* (λεπὶς, a scale), is applied, and the surface is said to be *lepidote*. These scales have sometimes a beautiful silvery appearance, as in Elæagnus. Surrounding the base of the leaves of Ferns, a brown chaffy substance occurs, consisting of elongated cells, to which the name of *ramentaceous hairs*, or, *ramenta* (*ramentum*, a shaving), has been given. In Palms also a similar substance occurs, called *reticulum* (*reticulum*, a net), or *mattulla*, (*matta*, a mat). *Prickles* or *aculei*, as in the Rose (fig. 191 *a*), are hardened hairs connected with the epidermis, and differ from spines or thorns, which have a deeper origin. *Setæ* are bristles or stiff hairs, and the surfaces on which they occur are said to be *setose* or *setaceous*. Some hairs, as those of Drosera, or sundew, have one or more spiral fibres in their interior.



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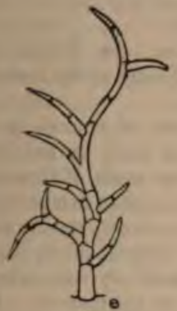

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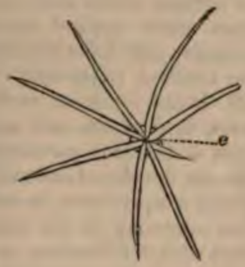

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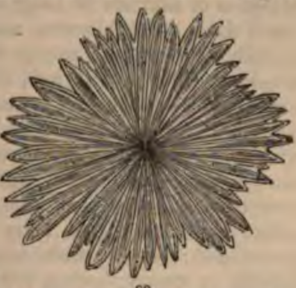

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58. Various names have been given to the different forms of hairs: they are *clavate* or *club-shaped* (*clava*, a club), gradually expanding from the base to their apex; *capitate*, having a distinct rounded head; *rough* or *scabrous*, with slight projections on their surface; *hooked* or *uncinate* (*uncus*, a hook), with a hook at their apex pointing downwards and to one side; *barbed* or *glochidiate* (γλωχὶς, a barb), with two or more hooks around the apex; *shield-like* or *peltate* (*pelta*, a buckler), when attached by their middle, and projecting horizontally

Fig. 80.—Partitioned, unbranched hair, from stem of Bryonia alba. 81. Partitioned, branched hair, from flower of Nicandra anomala. 82. Stellate or star-like hair, from leaf of Althæa rosea.
Fig. 83.—Scale or scaly hair, from leaf of Hippophaë rhamnoides.

on either side (fig. 84), as in many cruciferous plants; *ciliated* (*cilium*, an eye-lash), when surrounding the margin of leaves. On the pod of the Cowitch (*Mucuna pruriens*), hairs are produced with projections on their surface, which cause great irritation when applied to the skin. In Venus' Fly-trap (*Dionæa muscipula*), stiff hairs exist on the blades of the leaf (fig. 186 *e*), which, when touched, cause their closure.

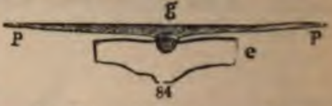

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Fig. 84.—Peltate hair of Malpighia, *p p*, arising from epidermis, *e*. *g*, The gland which communicates with the hair.

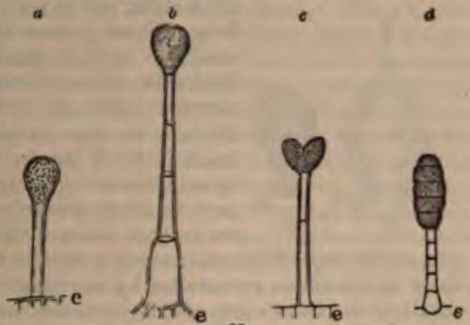
59. Hairs occur on various parts of plants; as the stem, leaves, flowers, seed-vessels and seeds, and even in the interior of vessels. Cotton is the hair surrounding the seeds of Gossypium herbaceum. Hairs are developed occasionally to a great extent on plants exposed to elevated temperatures, as well as on those growing on lofty mountains. When occurring on the organs of reproduction, they seem to be connected with fertilization, as the hairs on the style of Goldfussia or Ruellia, and the retractile hairs of Campanula. Different parts of plants are transformed into hairs; as may be seen in the flowering stalks of Rhus Cotinus, and in the calyx of Compositæ.

60. Names are given to the surfaces of plants according to the presence or absence of hairs, as well as the nature of the hairs which cover them. The following are the more important terms:—*Glabrous*, smooth, having no hairs; *hairy* (*pilosus*), furnished with hairs; *pubescent*, covered with soft, short, downy hairs; *villous*, having long, weak, often oblique hairs; *sericeous*, covered with long, closely appressed hairs, having a silky lustre; *hispid* (*hispidus*, *hirtus*), covered with long stiff hairs not appressed; *hirsute*, having long tolerably distinct hairs, not stiff nor appressed; *velvety*, (*velutinus*), with a dense covering of short down, like velvet; *tomentose*, covered with crisp, rather rigid, entangled hairs like cotton, which form a sort of felt (*tomentum*); *woolly*, with long curled and matted hairs like wool; *bearded* or *stupose*, (στύπη, tow), when hairs occur in small tufts.

61. The hairs which are most frequently met with in plants are called *lymphatic*, from their not being connected with any peculiar secretion. Those, on the other hand, which have secreting cells at their base or apex, are denominated *glandular*, and are not to be distinguished from glands, under which therefore they will be considered. Lymphatic hairs occur on parts exposed to the air, and are wanting in blanched plants. On young roots, cellular projections of the cuticle are seen (fig. 77), which may be called *radical* hairs. Young leaves and buds are frequently thickly covered with protecting hairs. In this instance the hairs arise chiefly from the veins; and as the leaves increase in size, and the veins are separated, the hairs become scattered,

and apparently less abundant. On the parts of the flower, coloured hairs occur which have been called *corolline.*

62. **Glands** are collections of cells forming secretions. The term has been vaguely applied to all excrescences occurring on the surfaces of plants. They are either *stalked* (*petiolate, stipitate*) or *not stalked* (*sessile*). The former may be called glandular hairs, having the secreting cells at the apex. Stalked glands, or glandular hairs, are either composed of a single cell, with a dilatation at the apex (fig. 85 *a*), or of several cells united together, the upper one being the secreting organ (fig. 85 *b*). In place of a single terminating secreting cell, there are occasionally two (fig. 85 *c*) or more (fig. 85 *d*). Hairs sometimes serve as ducts through which the secretion of glands is discharged; these are glandular hairs, with the secreting cells at the base. Such hairs are seen in the nettle (fig. 86), in Loasa or Chili nettle, and in Malpighia (fig. 84), and are commonly called *stings.* In the nettle they are formed of a single conical cell, dilated at its base (fig. 86 *b*), and closed at first at the apex, by a small globular button placed obliquely (fig. 86 *s*). This button breaks off on the slightest touch, when the sharp extremity of the hair enters the skin, and pours into the wound the irritating fluid which has been pressed out from the elastic epidermal cells at the base. When a nettle is grasped with violence, the sting is fractured, and hence no injury is done to the skin. The globular apex of glandular hairs sometimes forms a viscid secretion, as in the Chinese primrose and sundew. The hairs of the latter plant, by this secretion, detain insects which happen to alight on them.



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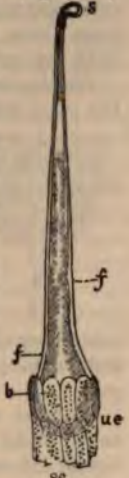

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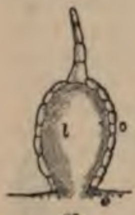
Fig 85.—Glandular hairs. *e*, Epidermis. *a*, Hair formed by a single cell from Sisymbrium chilense. *b*, Hairs formed of several cells terminated by a secreting cell, from flower-stalk of Antirrhinum majus. *c*, Hair composed of several cells, terminated by two secreting cells united laterally, from flower-stalk of Lysimachia vulgaris. *d*, Compound hair, terminated by several secreting cells united end to end, from Geum urbanum.

Fig 86.—Conical hair of Urtica dioica, or common nettle, ending in a button or swelling *s*, with a dilatation or bulb at its base *b*, which is surrounded by epidermal cells *u e*. In the hair are currents of granular matter *f f*.

63. When glands are sessile, they consist of epidermal cells either surrounding a cavity, or enclosing small secreting cells. In fig. 87, is represented a gland taken from the flower-stalk of Dictamnus albus, cut vertically, to show the cavity surrounded by cells, and filled with a greenish oil; while in fig. 88, there is a gland with a short thick stalk, full of cells, taken from Rosa centifolia. These figures show the transition from sessile to stalked glands. Some of the superficial cells of the epidermis are sometimes slightly elevated above the rest, and contain peculiar fluids. In the Ice-plant, the appearance of small pieces of ice on the surface is produced by cells containing a clear fluid, which is said to have an alkaline reaction, while that of the tissue around the vesicles is acid; in the Chick-pea, similar superficial cells contain a subacid fluid. Glandular depressions or pits occur, surrounded by secreting cells. At the base of the petals of the Crown-imperial, for instance, cavities are seen containing a honey-like fluid, secreted by what are called *nectariferous* glands. Cavities containing saccharine matter, surrounded by small thin-walled cells, are met with in the leaves of Acacia longifolia, also in Viburnum Tinus, and Clerodendron fragrans. The cavities communicate with the surface of the leaves by means of canals.



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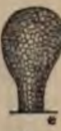

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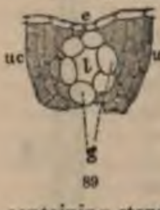
Glands are occasionally sunk in the epidermis, so as merely to have the apex projecting; at other times they lie below the epidermal cells, as in the Myrtle, Orange, St. John's-wort, and Rue. In the latter case they are sometimes called *vesicular*, and are formed by cells surrounding cavities containing oil (fig. 89). When they occur in the leaves, they give rise, when viewed by transmitted light, to the appearance of transparent points or dots. *Verrucæ*, or warts, are collections of thickened cells on the surface of plants, assuming a rounded form, and containing starch or other matters. *Lenticels*, or *Lenticular glands*, are cellular projections on the surface of the bark, arising from its inner part.



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64. **The Special Functions** of the Epidermis and its appendages, are to protect the parts beneath from various atmospheric and meteorological influences. In plants growing in dry climates, the epidermis

Fig. 87.—Gland from flower-stalk of Dictamnus albus, cut vertically, showing central cavity *l*, filled with greenish oil, and surrounded by a layer of cells *c*, which contain a red juice, and are connected with the epidermis *e*.

Fig 88.—Gland from Rosa centifolia. *e*, The epidermis.

Fig. 89.—Vesicular gland from Ruta graveolens, or Common Rue. *g*. Gland formed by large transparent cells, surrounding a central lacuna, *l*. *e*, Epidermis from upper surface of the leaf. *u c*, *u c*, Cells filled with Chlorophylle.

is often very thick, and coated with a waxy secretion, to prevent too great transpiration or exudation of fluids. In those which inhabit humid places, the epidermis is thin and absorbent; while in submerged aquatics, there is no proper epidermal covering. The stomata regulate the transpiration, opening and closing according to the state of humidity and dryness of the atmosphere surrounding them. When a plant is growing vigorously, the constant passage of fluids keeps the regulating cells around the stomata in a distended state, and thus opens the orifice; whereas, when the circulation is languid and the fluids are exhausted, the cells collapse and close the opening. The opinion that the succulency of plants is a sort of dropsical condition, caused by the absence of stomata to carry off the fluids, has not been confirmed by observation. Hairs, according to their structure, serve various purposes. Lymphatic hairs protect the surface, and regulate evaporation. Plants thickly covered with hairs, as Verbascum Thapsus, have been known to resist well an extended period of drought. Glandular hairs, and glands in general, form secretions which are employed in the economy of vegetation, or are thrown off as excretions no longer fitted for the use of the plant itself. Many of these secretions constitute important articles of materia medica. Lenticels keep up a connection between the air and the inner bark, and probably perform the function of stomata in the advanced period of the growth of the plant. They are considered, by Decandolle and others, as being the points where young roots are produced in certain circumstances, and on that account they have been called *Rhizogens* (ῥιζα, a root, and γεννάειν, to produce). They are conspicuous in Willows, the young branches of which form roots very readily when placed in moist soil. Some hairs occurring on the style of plants are called collecting hairs, from the functions which they perform in taking up the pollen. In the species of Campanula, these hairs are so formed, that after the pollen has been discharged, their upper part is drawn within the lower. In many hairs a circulation of fluids takes place, connected apparently with their nutrition and development (fig. 86). In the moniliform purple hairs on the stamens of Tradescantia, or Spiderwort, this movement may be easily seen under the microscope. The subject of the circulation in hairs will be considered under *Rotation* (p. 139).

STEM OR ASCENDING AXIS.

Forms of Stems.

65. The stem is that part of a plant which bears the leaves and flowers. It receives the name of *Caulis* in ordinary herbaceous plants which do not form a woody stem, *Truncus* in trees, *Caudex* in shrubs, *Culm* in grasses, and *Stipe* in Palms and Ferns. It is not always con-

spicuous. Plants with a distinct stem are called *caulescent;* those in which it is inconspicuous are *acaules.* Some plants are truly stemless, and consist only of expansions of cellular tissue, called a *Thallus,* and hence are denominated *Thallogens,* or *Thallophytes* (θάλλος, a frond, γεννάειν, to produce, φυτὸν, a plant). They have no true vascular system, but are composed of cells of various sizes, which sometimes assume an elongated tubular form, as in Chara. The cells are sometimes united in one or several rows, forming simple filaments, as in Confervæ; or branched and interlaced filaments, as in some Fungi; or membranous expansions, as in Lichens and sea-weeds.

66. Stems have usually considerable firmness and solidity, but sometimes they are weak, and either lie prostrate on the ground, thus becoming *procumbent,* or climb on plants and rocks by means of suckers like the Ivy, being then called *scandent,* or twist round other plants in a spiral manner like Woodbine, becoming *volubile.* Twining plants turn either from right to left, as the French bean, Convolvulus, Passion-flower, and Dodder; or from left to right, as Honeysuckle, Hop, and Tamus. Bryony tendrils twine from right to left, and left to right, alternately. In warm climates, twining plants (*lianas*) often form thick woody stems; while in temperate regions they are generally herbaceous. Exceptions, however, occur in the case of the Clematis, Honeysuckle, and Vine, the woody stems of which have received the name of *Sarmentum* (*sarmentum,* a twig, or cutting of a vine). Some stems are developed more in diameter than in height, and present a peculiar shortened and thickened aspect, as Testudinaria, or Tortoise-plant, and Cyclamen.

67. Stems have a provision for a symmetrical arrangement of leaves and branches,—*nodes* (*nodus,* a knot), or points whence leaf-buds are produced, being placed at regular intervals. No such provision occurs in roots which ramify irregularly, according to the nature of the soil. The intervals between nodes are called *internodes.* The mode in which branches come off from the nodes, gives rise to various forms of trees, such as pyramidal, spreading, or weeping; the angles formed with the stem being more or less acute or oblique. In the Italian Popler and Cypress the branches are erect, forming acute angles with the upper part of the stem; in the Oak and Cedar they are spreading or patent, forming nearly a right angle; in the weeping Ash and Elm they come off at an oblique angle; while in the weeping Willow and Birch, they are pendulous from their flexibility. The comparative length of the upper and under branches, also gives rise to differences in the contour of trees, as seen in the conical form of Spruce, and the umbrella-like form of the Italian Pine (*Pinus Pinea*).

68. Plants which form permanent woody stems above ground, are denominated *trees* and *shrubs,* while those in which the stems die down to the ground, and are not persistent, are called *herbs.* The

term *tree* (*arbor*) is applied to those plants which have woody stems many times exceeding the height of a man, the lower part free from branches being the trunk: a *shrub* (*frutex*) has a stem about three times taller than a man, and branches from near the base: an *undershrub* (*suffrutex*) does not exceed the length of the arm; while a *bush* (*dumus*) is a low diminutive shrub, with numerous branches near the base. The terms *arborescent*, *fruticose*, *suffruticose*, and *dumose*, are derived from these.

69. Stems have usually a round form; but they are sometimes compressed or flattened laterally, while at other times they are angular: being *triangular*, with three angles and three flat faces; *trigonous* (τρεῖς, three, and γωνία, an angle), with three convex faces; *triquetrous* (*triquetrum*, a triangle), with three concave faces; *quadrangular*, or square; *quinquangular*, or five-angled; *octangular*, or eight-angled, &c.

70. The stem has been called the *ascending axis*, from being developed in an upward direction. It does not, however, always ascend into the air; and hence stems have been divided into *aerial*, or stems which appear wholly or partially above ground; and *subterranean*, or those which are entirely under ground. The latter are often called roots, but they are distinguished by producing leaf-buds at regular intervals. The following are some of the more important modifications of stems:— The *Crown of the root* is a shortened stem, often partially under ground, which remains in some plants after the leaves, branches, and flower-stalks have withered. In this case the internodes are very short, and the nodes are crowded together, so that the plant appears to be stemless. It is seen in perennial plants, the leaves of which die down to the ground annually. A *Rhizome* or *root-stock* (fig. 90), is a stem which runs along the surface of the ground, being partially covered by the soil, sending out roots from its lower side, and leaf-buds from its upper. It occurs in Ferns, Iris, Hedychium, &c. By many the term *rhizome* is applied to stems creeping horizontally, whether they are altogether or only partially subterranean. A *Pseudo-bulb* is an enlarged bulbous-like aerial stem, common in Orchidaceous plants. It is succulent, often contains numerous spiral cells and vessels, and is covered with a thick epidermis. In the Kohl-rabi, a peculiar thickened turnip-like stem is met with. A *Soboles* is a creeping under-ground

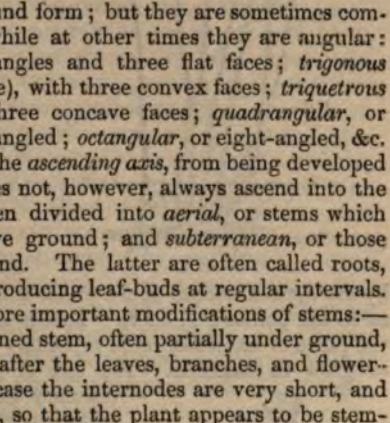

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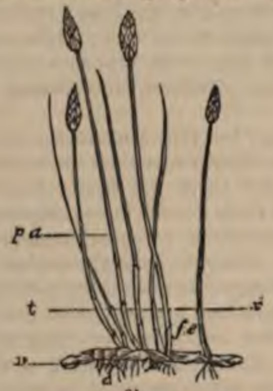
Fig. 90.—Portion of Rhizome, *r*, of Convallaria Polygonatum. *a*, A bud in the progress of development. *b*, A bud developed as a branch at the extremity of the rhizome. *c c*, Cicatrices or scars, indicating the situation of old branches which have decayed.

stem, sending roots from one part and leaf-buds from another, as in Couch grass, Carex arenaria, and Scirpus lacustris (fig. 91). It is often called a creeping root. A *Tuber* is a thickened stem produced by the approximation of the nodes and the swelling of the internodes, as in the potato (fig. 92 *t*). Tubers are sometimes aerial, occupying the place of branches, more especially when the potato has been made to grow in darkness. The *eyes* of the potato are leaf-buds. The ordinary herbaceous stem of the potato, when cut into slips and planted, sometimes forms branches from its base which assume the form of tubers. These tubers occasionally become nodulated, or elongated, or curved in various ways. Arrow-root is derived from the scaly tubers of Maranta arundinacea. A *Corm* is a solid underground stem which does not spread by sending out shoots, but remains of a rounded form, and is covered by thin scales on the outside (fig. 93). It occurs in Colchicum, Tulip, Crocus, and Gladiolus. It is distinguished from a root by sending off annually buds in the form of small corms or thickened branches, either from the apex as in



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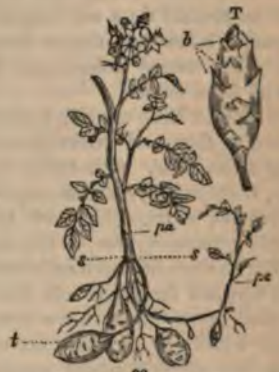

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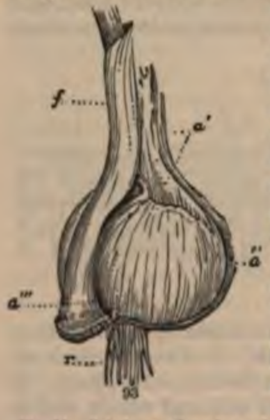

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Fig. 91.—Soboles, or Creeping subterranean stem, *r*, of Scirpus lacustris. *f e*, *f e*, Scales on the stem. *p a*, Aerial portion of the plant. *t t*, Level of the earth.

Fig. 92.—Lower portion of a potato plant. *s s*, Level of earth. *p a*, *p a*, Aerial portion bearing leaves. *t*, Subterranean portion of stem or tubers. *T*, Tuber showing eyes or leaf-buds, covered by scales, *b*, which are equivalent to leaves.

Fig. 93.—Corm or under-ground stem of Colchicum autumnale. *r*, Roots. *f*, Leaf. *a'*, Ascending axis of preceding year, withered. *a''*, Axis of the year. *a'''*, Point where axis of next year would be formed.

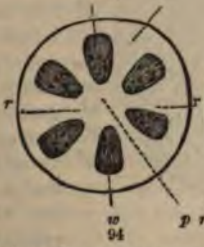
Gladiolus, or from the side as Colchicum (fig. 93 a''). These buds feed on the original corm a', and destroy it. It will be noticed afterwards, when leaf-buds and bulbs are considered.

Internal Structure of Stems.

71. Stems, according to their structure, have been divided into three classes:—*Exogenous* (ἔξω, outward, and γεννάειν, to produce), when the bundles of vascular tissue are produced regularly in succession externally, and go on increasing indefinitely in an outward direction. *Endogenous* (ἔνδον, within), when the bundles of vascular tissue are produced in definite bundles and converge towards the interior, additions being thus in the first instance made internally. *Acrogenous* (ἄκρος, summit), when the vascular bundles are developed at the same time and not in succession, the addition to the stem depending on the union of the base of the leaves and extension of the growing point or summit. The plants which exhibit these three kinds of stem, are distinguished also by the structure of their embryo. Thus exogenous stems are met with in plants having an embryo or germ which has two cotyledons or seed-lobes, hence they are called *Dicotyledonous* (δὶς, twice, and κοτυληδὼν, a seed-lobe); plants with endogenous stems have only one cotyledon, and are called *Monocotyledonous* (μόνος, one); while plants with acrogenous stems have no cotyledons, and are called *Acotyledonous* (α, privative). The terms connected with the embryo will be afterwards fully explained.

Exogenous or Dicotyledonous Stem.

72. The Exogenous or Dicotyledonous stem characterizes the trees of this country. It consists of a cellular and vascular system: the former including the outer bark, medullary rays, and pith; the latter, the inner bark, woody layers, and medullary sheath. In the early stage of growth, the young dicotyledonous stem is entirely cellular; but ere long fusiform tubes appear, forming bundles, having the appearance of wedges (fig. 94



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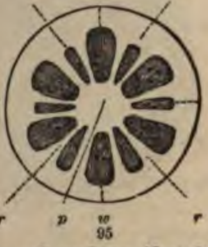

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Fig. 94.—Young Dicotyledonous or Exogenous stem. *w w*, Vascular bundles in the form of wedges. *p*, Pith. *r r r*, Medullary rays.

Fig. 95.—Same stem further advanced; the letters as in fig. 94, *n n n*, new vascular wedges interposed between those first formed.

w w) arranged in a circle round a central cellular mass of *pith* (fig. 94 *p*), which is connected to the outer part or *bark*, by means of cellular processes called *medullary rays* (fig. 94 *r r r*). At first, the cellular portion is large,—the pith, bark, and rays occupying a large portion of the stem; but by degrees new vascular bundles are formed, which are deposited between the previous ones (fig. 95 *n n n*). By this means the pith is more circumscribed, the medullary rays become narrow, and the bark more defined. Such is the structure presented by an annual herbaceous dicotyledonous stem, consisting of pith, a circle of fibro-vascular and woody tissue, medullary rays, bark, and epidermis.

73. The stems of trees and shrubs in their young state exhibit an arrangement similar to that represented as occurring in the herbaceous stem (fig. 95), with this difference, that the vascular circle is more firm and solid. As ligneous stems continue to grow, further changes take place by which their diameter is increased, and they are rendered more dense. The shoots or young branches given out annually, however, are similar in structure to annual herbaceous stems; and in making successive sections from the apex of a branch, which is succulent and green, to the base of a trunk, which is comparatively dry and hard, the various changes which take place can be easily traced. Fig. 96 represents a thin horizontal or *transverse* section of the upper part of a young branch of Acer campestre. In the centre, *m*, is the pith, very large at this period of growth, and occupying at least one-half of the whole diameter, its cells diminishing in size as they approach the circumference. Immediately surrounding the pith is a layer of a greenish hue, the medullary sheath, *e m*, from which the medullary rays *r m*, proceed towards the circumference, dividing the vascular circle into numerous compact segments, which consist of woody vessels, *f b*, and of porous vessels, *v p*. These are surrounded by a moist layer of greenish cellular tissue, *c*, called the cambium layer, which is covered by three layers of bark, *fc*, *ec*, and *p*, with laticiferous vessels, *v l*, the whole being enclosed by the epidermis, *e p*. On making a thin *vertical* section of a portion of the same branch, and viewing it under

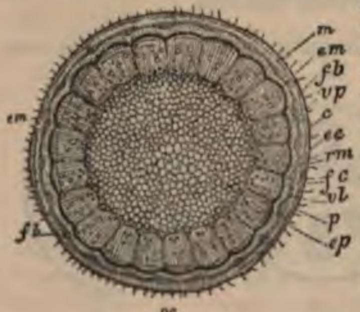

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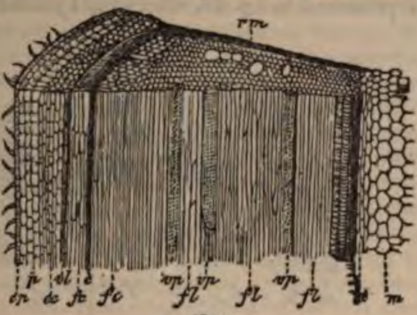
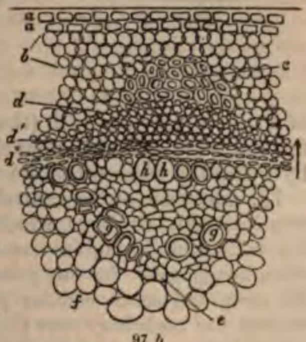
Fig. 96.—Horizontal section of young stem of Acer campestre, magnified twenty-six diameters. *m*, Pith. *e m*, *e m*, Medullary sheath. *f b*, *f b*, Woody bundles. *v p*, Porous vessels. *r m*, Medullary rays. *c*, Cambium. *f c*, Fibres of Endophlœum. *v l*, Laticiferous vessels. *e c*, Cellular envelope, Mesophlœum. *p*, Corky envelope, Epiphlœum. *e p*, Epidermis.

the microscope, the parts composing the different portions become more obvious (fig. 97 *a*). The pith, *m*, with its hexagonal cells decreasing in size outwards, surrounded by a narrow fibro-vascular zone; the medullary sheath, consisting chiefly of spiral vessels, *t*; the medullary ray, *r m*; the vascular zone, consisting of porous vessels, *v p*, of large diameter, and forming the large round apertures seen in a transverse section; the woody fibres, *f l*, with their thick walls and smaller apertures; the inner bark or liber, *f c*, with the layer of cambium cells, *c*; the second layer of bark, or the cellular envelope, *e c*, with the laticiferous vessels, *v l*; the outer or suberous layer of bark, *p*, with the thin layer of epidermis, *e p*, having hairs scattered over its surface. A transverse section of a bundle of vascular tissue of a dicotyledonous plant, magnified 230 times, is represented in fig. 97 *b*. The arrow indicates the direction from within outwards. We here perceive the vascular bundle surrounded by a large-celled tissue (*a á b f*). The quadrangular cells, *a á*, form the epidermis, to which succeeds the cellular tissue of the bark, *b*. The latter surrounds a bundle of bast fibres, *c*, and ligneous layers of inner bark, with laticiferous vessels, *d d'*, which are separated in the direction towards the interior, by a layer of cambium cells, *d''*, from the proper vascular tissue, consisting of pitted vessels with thick walls, *g g*, and others with thin walls, *h h*, mixed with woody tubes, *e*.



97 *a*



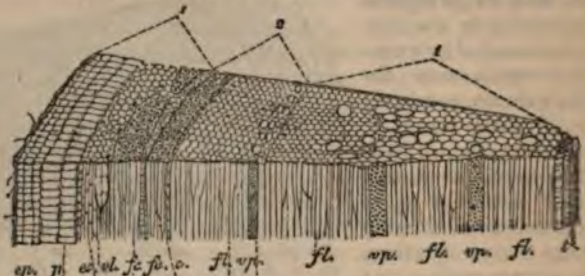
97 *b*

74. Such is the structure of a young shoot during the first year of its growth. At the end of a second year the shoot is found to have increased in diameter by the formation of a zone of vessels consisting of porous and woody tissue, and a zone of fibrous bark, the medullary

Fig. 97 *a*.—Vertical section of the same stem more highly magnified. *t*, Tracheæ or spiral vessels. *f l*, *f l*, *f l*, Woody fibres. The other letters as in fig. 96.

Fig. 97 *b*.—Transverse section of a bundle of vascular tissue of a Dicotyledonous plant. *a á*, Epidermis. *b*, Large celled tissue of bark. *c*, Fibres of bast layer. *d*, *d'*, Woody layers and laticiferous vessels of inner bark. *d''*, Cambium cells. *gg*, and *hh*, Large pitted vessels. *e*. Woody tubes. *f*, Large cells.

rays being at the same time continued from within outwards. This is represented in fig. 98, where (1, 1) indicates the section of the stem of the first year's growth (the letters referring to the same parts as in figs. 96, 97); and (2) shows the interposed zones of the second year, by which the diameter of the stem is increased.



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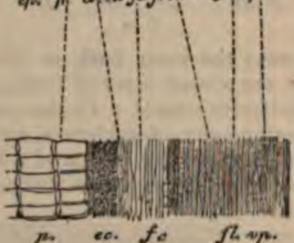
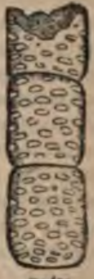


98 bis.



98 ter.

75. **The Pith,** or the central part of a dicotyledonous stem, is composed of cellular tissue, which is developed in an upward direction, the cells diminishing in size towards the circumference, and being often hexagonal. In the young plant it occupies a large portion of the stem, and sends cellular processes outwards at regular intervals to join the medullary rays (figs. 94, 95, *p*). The pith has at first a greenish hue, and is full of fluid, but in process of time it becomes pale-coloured, dry, and full of air. These changes take place first in the central cells. Sometimes the pith is broken up into cavities, which have a regular arrangement, as in the Walnut and the Jessamine; it is then called *discoid* or *disciform* (δίσκος, a disc, from the circular partitions). At other times, by the rapid growth of the outer part of the

Fig. 98.—Vertical section of a branch of Acer campestre, two years old, where (1, 1) indicates the portion formed the first year, and (2) that formed the second. The letters as in figs. 96 and 97.

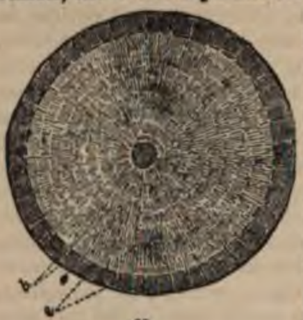
Fig. 98 *bis*.—Certain parts of the preceding magnified in order to show the structure of the vessels and cells, as well as their form and direction. Fig. 98 *ter*.—A portion of a porous vessel magnified.

stem, the pith is ruptured irregularly, and forms large cavities, as in the fistular stem of Umbelliferous plants. Circumscribed cavities in the internal cellular portions of stems are by no means unfrequent, arising either from rupture or absorption of the cells. In some rare instances, vessels occur in pith, as in Elder, Pitcher-plant, and Ferula; and occasionally its cells are marked by pores indicating the formation of secondary deposits. The extent of pith varies in different plants, and in different parts of the same plant. In Ebony it is small, while in the Elder it is large. In the Shola plant, a species of Æschynomene, the interior of the stem is occupied almost entirely by cellular tissue or pith; from this a kind of rice-paper is made by cutting thin sections in a circular manner. The same kind of tissue occurs in the Papyrus of the Nile. Large pith is also seen in Aralia papyrifera, or Chinese Rice-paper plant. When the woody circle of the first year is completed, the pith remains stationary as regards its size, retaining its dimensions even in old trunks, and never becoming obliterated.

76. **The Medullary Sheath** is the fibro-vascular layer immediately surrounding the pith. It forms the inner layer of the vascular bundle of the first year (fig. 97 *t*), and consists chiefly of true spiral vessels, which continue to exercise their functions during the life of the plant, and which extend into the leaves. With the spiral vessels there are a few woody fibres intermingled. The processes from the pith are prolonged into the medullary rays between the vessels of the sheath.

77. **Woody Layers.** During the first year, the vascular circle consists of an internal layer of spiral vessels forming the medullary sheath, and external bundles of porous and ligneous vessels. In subsequent years the layer of spiral vessels is not repeated, but concentric zones of porous vessels (fig. 98 *ter.*), and pleurenchyma are formed, constituting what are commonly called the woody circles of trees. The vascular bundles, from their mode of development in an indefinite manner externally, have been called *Exogenous;* and, for the same reason, Schleiden has denominated them *Indefinite.* Exogenous plants have sometimes received the name of *Cyclogens* (κύκλος, a circle), in consequence of exhibiting concentric circles in their stems. On a transverse section, each zone or circle is usually seen to be separated from that next to it by a well-marked line of demarcation. This line, as in the Oak (figs. 99, 100), and in the Ash, is indicated by holes which are the openings of large porous vessels; the remainder of the tissue in the circle being formed by pleurenchyma, with thickened walls and of smaller calibre. In some trees, as the Lime, Hornbeam, and Maple, the line is by no means so well marked, as the openings are smaller and more generally diffused; but there is usually a deficiency of porous vessels towards the outer part of the circle. In cone-bearing plants, as the Fir, in which the woody layers consist entirely of punctated woody tissue (fig. 47), without any large porous

vessels, the line of separation is marked by the pleurenchyma becoming dense and often coloured. In some kinds of wood, as Sumach, the zones are separated by a marked development of cellular tissue. The separation between the zones is said to be owing to the interruption in the growth of the tree during autumn and winter, and hence it is well defined in trees of temperate and cold climates. But even in tropical trees, the lines, although often inconspicuous, are still visible; the dry season, during which many of them lose their leaves, being their season of repose.



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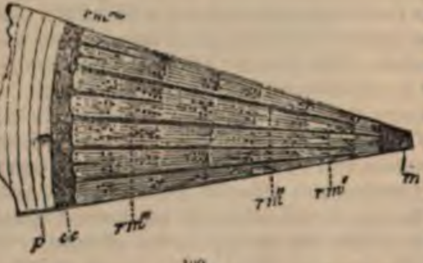

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78. The woody layers vary in their texture at different periods. At first the vessels are pervious and full of fluid, but by degrees thickening layers are deposited which contract their canal, and sometimes obliterate it. The first-formed layers are those which soonest become thus altered. In old trees, there is a marked division between the central *Heart-wood* or *Duramen (durus*, hard), and the external *Sap-wood* or *Alburnum* (*albus*, white); the former being hard and dense, and often coloured, with its tubes dry and thickened; while the latter is less dense, is of a pale colour, and has its tubes permeable by fluids. The difference of colour between these two kinds of woods is often very visible. In the Ebony tree, the duramen or perfect-wood, is black, and is the part used for furniture, &c.; the alburnum is pale: in the Beech, the heart-wood is light-brown: in the Oak, deep-brown: in Judas tree, yellow; in Guaiacum, greenish. The alteration in colour is frequent in tropical trees. In those of temperate climates, called *white-wood*, as the Willow

Fig. 99.—Horizontal section of the stem of an oak eight years old. *b*, Wood, showing concentric circles or zones, separated by points which correspond to the opening of the large porous vessels, or Bothrenchyma. *c*, Bark, showing also eight concentric circles, thinner and less distinct. The wood and bark are traversed by medullary rays, some of which extend from the bark to the pith, and others reach only a certain way inwards.

Fig. 100.—Horizontal section of two woody bundles of Cork oak, separated from each other by the medullary ray, $r\,m'$. The two primary bundles are divided by secondary rays, $r\,m''$, rm''', $r\,m''''$, which vary in extent according to the period when they originated. *m*, Pith. *c c*, Cellular envelope. *p*, Corky envelope, which is highly developed and exhibits several layers.

and Poplar, no change in colour takes place; this is also the case in the Chestnut and Bombax. The relative proportion of alburnum and duramen differs in different trees. Duhamel says that in the oak, six inches in diameter, the alburnum and duramen are of equal extent; in a trunk one foot in diameter, they are as two to seven; in a trunk two feet in diameter, as one to nine. The heart-wood is more useful than the sap-wood, and less liable to decay. The wood of different trees varies much in its durability. Pieces of wood, 2⅝ inches square, were buried to the depth of one inch in the ground, and decayed in the following order:—Lime, American Birch, Alder, and Aspen, in three years; Willow, Horse-chestnut, and Plane, in four years; Maple, Red Beech, and Birch, in five years; Elm, Ash, Hornbeam, and Lombardy Poplar, in seven years; Robinia, Oak, Scotch Fir, Weymouth Pine, Silver Fir, were decayed to the depth of half an inch in seven years; while Larch, common Juniper, Virginian Juniper, and Arbor Vitæ, were uninjured at the end of that time.

79. From the mode in which the woody layers are formed, it is obvious that each vascular zone is moulded upon that which precedes it; and as in ordinary cases each woody circle is completed in the course of one year, it follows, that, by counting the concentric circles, the age of a tree may be ascertained. Thus fig. 99 represents an oak eight years old having eight woody layers, *b*. This computation can only be made in trees having marked separations between the circles. There are, however, many sources of fallacy. In some instances, by interruption to growth, several circles may be formed in one year, and thus lead to an erroneous estimate. Care must be taken to have a complete section from the bark to the pith, for the circles sometimes vary in diameter at different parts of their course, and a great error might occur from taking only a few rings or circles, and then estimating for the whole diameter of the tree. When by the action of severe frost, and other causes, injury has been done to the tender cells from which the young wood is developed, while, at the same time, the tree continues to live, so as to form perfect woody layers in subsequent years, the date of the injury may be ascertained by counting the number of layers which intervene between the imperfectly formed circle and the bark. In 1800, a Juniper was cut down in the forest of Fountainbleau, exhibiting near its centre a layer which had been affected by frost, and which was covered by ninety-one woody layers, showing that this had taken place in the winter of 1709. Inscriptions made in the wood become covered, and may be detected in after years when a tree is cut down; so also wires or nails driven into the wood. As the same development of woody layers takes place in the branches as in the stem of an Exogenous tree, the time when a branch was first given off may be computed by counting the circles on the stem and branch respectively. If there are fifty circles, for instance, in the trunk,

thirty in one branch, and ten in another, then the tree must have been twenty years old when it produced the first, and forty when it formed the other.

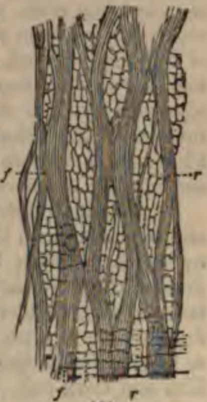
80. In Exogenous stems the pith is not always in the centre. The layers of wood on one side of a tree may be larger than those on the other, in consequence of more full exposure to light and air, or the nature of the nourishment conveyed, and thus the pith may become *excentric*. Zones vary in size in different kinds of trees, and at different periods of a plant's life. Soft wooded trees have usually broad zones, and old trees form smaller zones than young ones. There are certain periods of a plant's life when it seems to grow most vigorously, and to form the largest zones. This is said to occur in the oak between twenty and thirty years of age.

81. **Cambium.**—External to the woody layers, and between them and the bark, there is a layer of mucilaginous semifluid matter, which is particularly copious in spring, and to which the name of *Cambium* (*cambio*, I change, from the alterations that take place in it) has been given (figs. 96, 97 *c*). In this substance cells are formed, called cambium cells, of a delicate texture, in which the protoplasm and primary utricle are conspicuous. These cells undergo changes, so as to assume an elongated fusiform shape, and ultimately become thickened pleurenchyma. So long as the primary utricle can be detected, they appear to be in an active state, and capable of developing new cells. This cambium layer marks the separation between the wood and the bark, and may be regarded as constituting the active formative tissue of Dicotyledonous stems. It constitutes the *thickening zone*, by means of which the stem is enlarged—the cambium cells situated most internally being subservient to the purposes of the wood formation, while the external ones give origin to the new bark. According to Schacht this is the proper nourishing tissue.

82. **Bark or Cortical** (*cortex*, bark) **System**, lies external to the wood, and, like it, consists of several layers. In the early state it is entirely cellular, and is in every respect similar to the pith; but, as the vascular bundles are developed, the bark and pith are separated, and the former gradually becomes altered by the formation of secondary deposits. The bark consists of a cellular and vascular system. In this respect it resembles the wood, but the position and relative proportion of these two systems is reversed. In the bark the cellular system is external, and is much developed; while the vascular is internal, and occupies comparatively a small space. The cellular portion of the bark consists of an external layer, or *Epiphlæum* (ἐπί, upon, on the outside, and φλοιός, bark), and the cellular envelope, or *Mesophlæum* (μεσὸς, middle; while the vascular system forms the internal portion called *Liber*, or *Endophlæum* (ἔνδον, within).

83. The inner bark, or *endophlæum* (fig. 98 *f c*), is composed of

elongated pleurenchyma mixed with laticiferous vessels and some cellular tissue. It is separated from the wood by the cambium layer. The pleurenchymatous tubes are thickened by concentric deposits in their interior, and thus they acquire a great degree of tenacity. The liber of the Lime tree and of Antiaris saccidora, the sack-tree of Coorg, are used to form mats, cordage, and bags; and the toughness of the fibres of the inner bark of flax, hemp, and of many of the nettle and mallow tribe, render them fit for various manufacturing purposes. The liber is sometimes called the *bast-layer*, from its uses. Occasionally it is continuous and uninterrupted, as in the Vine and Horse-chestnut; at other times, as in the Oak, Ash, and Lime, the fibres are separated during the progress of growth, and form a sort of net-work, in the interstices of which the medullary rays are seen. The fibres of the lace-bark tree (*Lagetta lintearia*) are thus formed. In fig. 101, is represented the bark of Daphne Laureola; *f* indicating the woody fibres of liber, and *r* the medullary rays. The endophlœm increases by layers on its inside, which are thin, and may be separated like the leaves of a book, and hence the application of the name *liber*. The term *liber* may be derived from the fact of the inner bark being used for writing upon.



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84. The cellular envelope, or *mesophlœum*, lies immediately on the outside of the liber. It consists of polyhedral, often prismatical cells (fig. 98 *bis*, *e c*), usually having chlorophyll, or green colouring matter, in their interior, but sometimes being colourless and containing raphides. They are distinguished from those of the epiphlœum by their form and direction, by their thicker walls, their green colour, and the intercellular spaces which occur among them. This covering is usually less developed than the outer suberous layer, but sometimes, as in the Larch and common Fir, it becomes very thick, and separates like the epiphlœum. In the cellular envelope laticiferous vessels occur.

85. The *Epiphlœum* is the outer covering of the bark, consisting of cells which usually assume a cubical or flattened tabular form (fig. 98 *bis*, *p*). The cells have no chlorophyll in their interior, are placed close together, and are elongated in a horizontal direction; and thus they are distinguished from the cells of mesophlœum. In the progress of growth they become often of a brown colour. This covering may be composed of a single layer of tabular cells; but in some trees it consists of numerous layers, forming the substance called *cork*, which

Fig. 101.—Network formed by liber of Daphne Laureola. *f f*, Fibrous bundles. *r r*, Medullary rays.

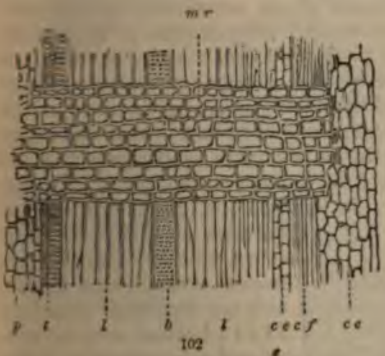
is well seen in *Quercus suber*, the Cork-oak (fig. 100 *p*); hence the name *suberous*, or *corky layer*, which is given to it. The form of its cells varies in some instances, being cubical at one part, and more compressed or tabular at another, thus giving rise to the appearance of separate layers. After a certain period (sometimes eight or nine years), the corky portion becomes dead, and is thrown off in the form of thickish plates, leaving a layer of tabular cells or *periderm* below. On the exterior of the epiphlœum is situated the epidermis, which has already been described (¶ 47). It is formed of a layer of cells, which in woody stems serve only a temporary purpose, becoming ultimately dry, and being thrown off in the form of plates or shreds

86. The bark, in its increase, follows an order exactly the reverse of that which occurs in the woody layers. Its three portions increase by additions to their inside. The layers of liber owe their increase to the cambium cells, which, by their constant reproduction, mark the separation between the vascular bundles of the wood, and the fibres of the endophlœum. These layers are often so compressed and united together as to be counted with difficulty, while at other times they are separated by rings of cellular tissue, and thus remain conspicuous. In the case of the cellular portions of the bark, there are also successive additions, sometimes to a great extent, but they do not usually exhibit any marked divisions.

87. As the additions are made to the woody layers on the outside, and to the bark on the inside, there is a constant distension going on, by which the bark becomes compressed, its layers of liber are condensed, the fibres are often separated so as to form meshes (as in the lace-bark), its epidermis is thrown off, and the epiphlœum is either detached along with it, or, when thick, is ruptured in various ways, so as to give rise to the rugged appearance presented by such trees as the Elm and Cork-oak. In some instances the bark is very distensible, and its outer cellular covering is not much developed, so that the surface remains smooth, as in the Beech. The outer suberous layer sometimes separates with the epidermis, in thin plates or scales. In the Birch, these have a white and silvery aspect. There is thus a continual destruction and separation of different portions of the bark. The cellular envelope and liber may remain while the epiphlœum separates, or they also may be gradually pushed off—the parts which were at first internal becoming external. In the case of some Australian trees, both the cellular and fibrous portions are detached in the form of thin flakes, and occasionally each annual layer of liber throws off that which preceded it. The epidermis separates early, and no renewal of it takes place. There is, however, an internal covering, which is formed of various portions of the bark. To this covering the name *Periderm* (περὶ, around, and δέρμα, skin) has been given by Mohl.

88. From the mode in which the outer layers of bark separate, it follows that inscriptions made on them, and not extending to the wood, gradually fall off and disappear. A nail driven into these layers ultimately falls out. In consequence of the continued distension of an exogenous stem, it is found that woody twining plants cause injury, by interrupting the passage of their fluids. A spiral groove may thus be formed on the surface of the stem, by the compression exercised by a twining plant, such as honeysuckle. From what has been stated relative to the changes which take place in the bark, it will be understood that it is often difficult to count its annual layers, so as to estimate the age of the tree by means of them. This may, however, be done in some cases, as shown at fig. 99, where there are eight layers of bark, *e*, corresponding to eight woody layers, *b*.

89. **Medullary Rays or Plates.**—While the bark and pith become gradually separated by the intervention of vascular bundles, the connection between them is kept up by means of processes called *medullary rays* (figs. 94, 95 *r*). These form the *silver grain* of carpenters; they communicate with the pith and the cellular envelope of the bark, and they consist of cellular tissue, which becomes compressed and flattened so as to assume a muriform appearance (fig. 102 *m r*). At first they occupy a large space (fig. 94 *r*); but as the vascular bundles increase, they become more and more narrow, forming thin laminæ or plates, which separate the woody layers. On making a transverse or horizontal section of a woody stem, the medullary rays present the



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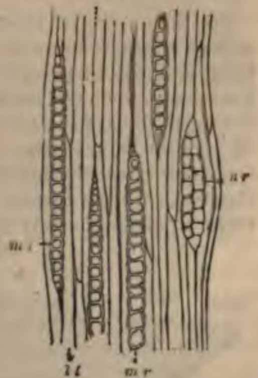

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Fig. 102.—Vertical section of a one-year old branch of Acer campestre highly magnified, and extending from the pith to the bark, parallel to the medullary rays. *m r*, A medullary ray or plate extending from the pith, *p*, to the bark, *c e*, crossing tracheæ, *t*, woody fibres, *l*, porous vessels, *b*, and cortical fibres, *c f*.

Fig. 103.—Vertical section of the same branch perpendicular to medullary rays. *l l*, Woody fibres which interlace, leaving spaces, *m r*, *m r*, *m r*, where the medullary rays pass.

aspect of narrow lines running from the centre to the circumference (figs. 99, 100 *r m*); and in making a vertical section of a similar stem through one of the rays, the appearance represented in fig. 102 will be observed, where a medullary ray, *m r*, composed of flattened muriform cells passes from the pith, *p*, to the cellular envelope, *c e*, crossing the tracheæ of the medullary sheath, *t*, the ligneous tissue, *l*, the porous vessels of the wood, *b*, and the fibres of the liber, *c f*. The laminæ do not by any means preserve an uninterrupted course from the apex to the base of the tree. They are broken up by the intervention of woody fibres, as seen in a vertical section of a woody stem (fig. 103), perpendicular to the medullary rays *m r*, *m r*, *m r*, which are separated by interlacing woody fibres, *l l*. The medullary rays are usually continuous from the pith to the bark, additions being made to them as they proceed outwards. But, occasionally, secondary rays arise from the outer cells, which pass only to a certain depth between the vascular bundles, as in the Cork-oak (fig. 100, *r m‴*, *r m*,″ *r m⁗*). Medullary rays are conspicuous in the Cork-oak, Hazel, Beech, Ivy, Clematis, Vine. They are not so well marked in the Lime, Chestnut, Birch, Yew.

Anomalies in the Structure of the Exogenous Stem.

90. The stems of Dicotyledonous plants occasionally present anomalous appearances in the structure and arrangement of their wood, bark, and medullary rays. In place of concentric circles, there are sometimes only a few rows of wedge-shaped vascular bundles produced during the life of the plant, additions being made by the interposition of bundles of a similar kind annually, resembling in this respect the formation of woody bundles in the early growth of herbaceous plants (fig. 95). In the Pepper tribe, Aristolochiaceæ, and Menispermaceæ, these anomalous stems occur. In Gnetum (fig. 104), the vascular bundles, *b b b b b b b*, form zones, which are each the produce of several years' growth, and are separated by layers, *l l l l l l*, which may be considered as representing different zones of liber.

In some of the Menispermum tribe, the separating layers are of a cellular and not of a fibrous nature. In Banisteria nigrescens (fig. 105), the young stem (1) presents a

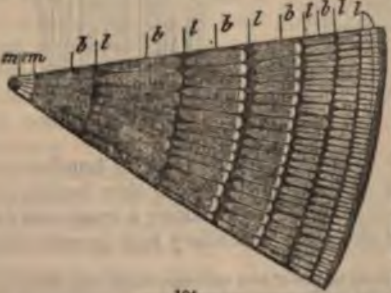

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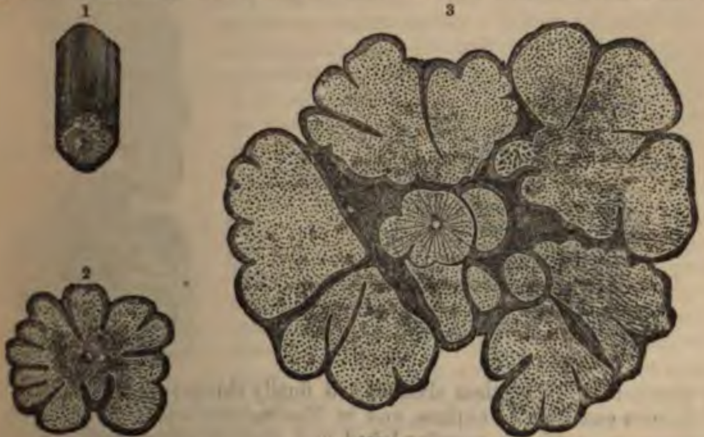
Fig. 104.—Horizontal section of stem of Gnetum. *m*, Pith. *e m*, Medullary sheath. *b b b b b b b*, Woody bundles forming seven concentric zones, each of which is the produce of several years. *l l l l l l*, Fibres of liber forming interposed circles, equal in number to the woody zones.

four-lobed surface; the lobes gradually deepen (2), and ultimately (3) the stem is divided into a number of separate portions, the central one of which alone exhibits pith and medullary rays. The portions are separated by interposed cortical layers.

Many of the Malpighiaceæ, Sapindaceæ, and Bignoniaceæ of Brazil, exhibit stems in which the woody layers are arranged in a very irregular manner. In the stem of Calycanthus floridus, and of some Brazilian Sapindaceæ, such as Paullinia pinnata (fig. 106), Serjania triternata and Selloviana, there is a central woody mass with from three to ten small secondary ones around it. Each of the masses contains true pith, apparently derived from the cortical cellular tissue, or from the original medullary centre. Gaudichaud and Jussieu state that around these separate collections of pith, there is a medullary sheath and spiral vessels. No annual rings have been detected in the secondary masses, but medullary rays exist, usually in their outer portion (fig. 106). In these anomalous Sapindaceæ, the central and lateral woody masses are enclosed in a common bark, with a continuous layer of liber. Some have supposed that the lateral masses are undeveloped branches united together under the bark; but Treviranus considers them as connected with the formation of leaves, and as depending on a peculiar tendency of the vascular bundles to be developed independently of each other round several centres.



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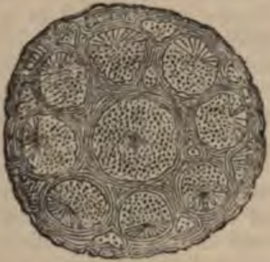
In some Bignoniaceæ (fig. 107), the layers of wood are divided in

Fig. 105.—Horizontal section of stem of Banisteria nigrescens at different ages. 1. Stem presenting four superficial lobes. 2. Showing six deeper lobes, with intermediate divisions. 3. The lobes separated by cellular tissue, the middle one alone having pith and medullary sheath. The points indicate the orifices of porous vessels.

a crucial manner into four wedge-shaped portions by the intervention of plates differing in texture from the ordinary wood of the plant, and probably formed by introversion, or growing inwards of the liber. In some Guayaquil Bignonias, Gaudichaud perceived first four of these plates, next eight, then sixteen, and finally thirty-two. In Aspidosperma excelsum of Guiana, and in Heteropterys anomala (fig. 108), the stem assumes a peculiar lobed and sinuous aspect, and in some woody climbing plants, pressure causes the stems to become flattened on the side next the tree on which they are supported, while from being twisted alternately in different directions, they present a remarkable zigzag form, having the woody layers developed only on one side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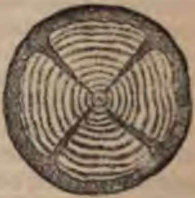
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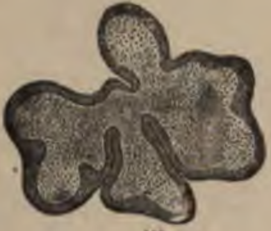
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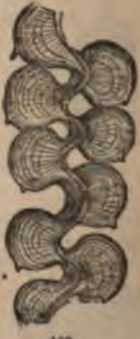
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Fig. 106.—Horizontal section of the stem of Paullinia pinnata, one of the Sapindaceæ of Brazil, showing numerous secondary woody masses, surrounding a central one. Each of the separate masses has pith, often excentric, with a medullary sheath, containing spiral vessels, and a few medullary rays chiefly towards the circumference of the stem.

Fig. 107.—Horizontal section of the stem of Bignonia capreolata, showing the crucial division of the woody layers

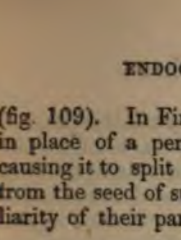
Fig. 108.—Horizontal section of stem of Heteropterys anomala, one of the Brazilian Malpighiaceæ, showing an irregularly lobed surface. The dots indicate porous vessels.

Fig. 109.—Fragment of a stem of a climbing species of Banisteria (B. scandens) showing the affects of compression.

(fig. 109). In Firs the wood is occasionally produced in an oblique in place of a perpendicular manner, thus injuring the timber, and causing it to split in an unusual way. The young plants produced from the seed of such twisted-wooded firs, are said to inherit the peculiarity of their parents.

Endogenous or Monocotyledonous Stem.

91. This kind of stem is composed of cells and vessels which are differently arranged from those of the Exogenous stem. The vascular bundles are scattered through the cellular tissue, and there is no distinction between pith, wood, or bark. There are no medullary rays, nor concentric circles (fig. 110). In the young state, the centre of the stem is occupied entirely by cells, which may be said to represent pith, and around this the vessels are seen increasing in number towards the circumference. The central cellular mass has no medullary sheath. In some cases its cells are ruptured, and disappear during the progress of growth, leaving a hollow cavity (fig. 111); but in general it remains permanent, and is gradually encroached upon by the development of the vascular system. The latter consists of vessels arranged in *definite* bundles, which do not increase by additions to their outside after being once formed, although they are developed in a progressive manner. These bundles may be considered as representing the vascular wedges, produced during the first year of an exogenous stem's growth (fig. 94). They consist of woody vessels enclosing some cellular tissue between them, with spiral and porous vessels. The outer part of the stem is not formed by a separable bark, but consists of a dense mass of fibrous tissue, mixed with laticiferous vessels and cells. It is intimately connected to the inner part of the stem, without the intervention of medullary rays.



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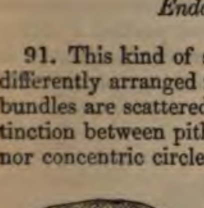

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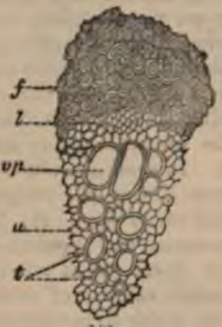
92. On making a transverse section of a young endogenous stem (fig. 112), there is observed a mass of cells or utricles, *u*, of various sizes, often small in the vicinity of the vascular bundles, spiral vessels or tracheæ, *t*, large porous vessels, *v p*, laticiferous vessels, *l*, and woody

Fig. 110.—Part of the stem of Asparagus cut transversely, showing the vessels as points distributed through the cellular tissue. *l*, Leaf in the form of a scale.

Fig. 111.—Transverse section of stem of Phragmites communis, or common reed. The cellular tissue in the centre has disappeared, leaving a fistular or hollow stem, with a ring of cells and vessels, the latter indicated by dots. *n*, Node where the fibres cross, so as to form a solid partition.

fibres, *f*, resembling those of liber, thickened by internal deposits. A similar section of a further advanced endogenous stem, as of a Palm (fig. 113), shows numerous bundles of vessels dispersed irregularly in cellular tissue; those near the centre, *m*, being scattered at a distance from each other, while those towards the outside are densely aggregated, so as to form a darkish zone, *b*, and are succeeded at the circumference by a paler circle of less compact vessels, *l*, with some compressed cells, covered by an epidermis, *e*. The peripherical portion, *l*, differs from *true* bark, in not being separable from the rest of the tissue. It has received the name of *false* bark, and consists of the epidermal cells, *e*, and what has been called the cortical integument, *l*. This portion of the stem is often very inconspicuous, but sometimes it is much developed as in Testudinaria elephantipes, in which it is rugged, and is formed of a substance resembling cork in many respects.



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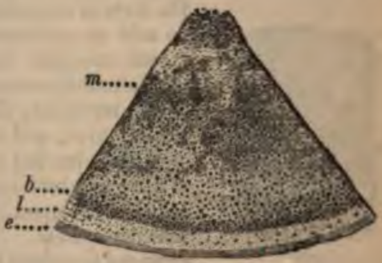

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93. Mohl states that, in the stem of a Palm, there may be distinguished a central region, a fibrous layer, and a cortical region; and the same divisions are pointed out by Henfrey in the stem of Sparganium ramosum and other monocotyledons. The central portion, representing the pith of dicotyledons, consists in Sparganium of spherical cells, containing starch, while the cortical or outer portion is formed by irregular cells, which are usually destitute of starch.

94. It was at one time supposed that the woody portion of these stems was increased by additions to the centre, so that the first-formed

Fig. 112.—Horizontal section of a vascular bundle from the stem of a Palm (*Corypha frigida*). *t*, Tracheæ, or spiral vessels. *v p*, Large porous vessels. *u*, Cells or utricles of various kinds surrounding the vessels, and forming the parenchyma. *l*, Laticiferous vessels. *f*, Fibres analogous to those of liber, thickened by concentric deposits.

Fig. 113.—Transverse section of part of the stem of a Palm (*Astrocaryum Murumuru*). *m*, Central or medullary portion in which the woody bundles are distant and scattered. *b*, External woody portion, where the fibres are numerous and densely aggregated, so as to form a dark zone. *l*, Paler circle of more slender and less compact fibres, which may be considered as analogous to liber. *e*, Cellular epidermal portion.

fibres were gradually pushed towards the circumference by those which succeeded them, in the manner represented in fig. 114, 1: hence the term Endogenous (ἔνδον, within, and γεννάειν, to produce), meaning internal growth. But Mohl has shown that this was not strictly correct. For although the fibres connected with the leaves, in the first instance, are directed towards the centre, and are therefore always internal to those previously formed, yet, when they are traced downwards, they are found not to continue in a parallel direction, but to arch outwards, so as ultimately to reach the circumference. Hence, the newly-formed fibres really become external at the base, although internal above. On making a vertical section of an endogenous stem, as of a Palm, there is observed an interlacing of fibres, similar to what is represented in fig. 114, 2, where the four vascular bundles, *a b c d*, are first directed towards the centre, and then curve outwards towards the circumference, so that those last formed ultimately become external. The term Endogenous, will, therefore, only apply strictly to the fibres at the early part of their course. On this account, the terms Endogenous and Exogenous have been recently discarded by many writers, the terms Monocotyledonous and Dicotyledonous being substituted. The true distinction between Exogenous and Endogenous stems consists in this, that in the former, the woody or vascular bundles increase indefinitely at their periphery, while in the latter, they are arrested in their transverse growth at a definite epoch. The investing bark of the former permits an unlimited extension of woody growth beneath it; the

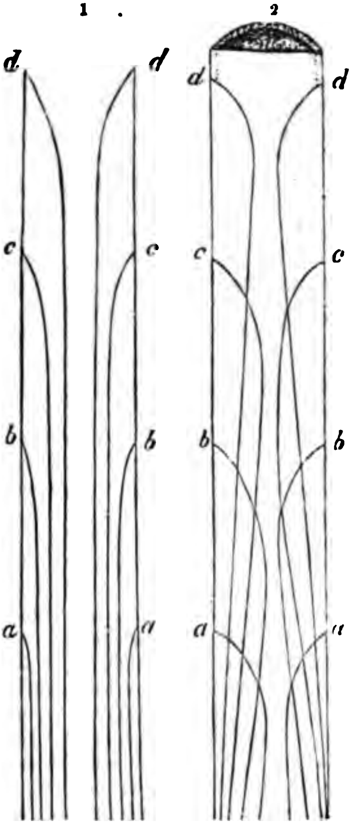

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Fig. 114.—Figures to represent the arrangement of four pairs of vascular bundles (*a a*, *b b*, *c c*, *d d*), in endogenous stems. 1. According to the old idea of internal development throughout the stem. 2. According to the view of Mohl, who has shown that the fibres interlace, and that those which are at first internal, become external, lower down.

fibrous cortical layer of the latter maintains an intimate union with the general structure which prevents unlimited increase in diameter. Hence we find that true endogenous stems do not attain the enormous diameter exhibited by some exogenous trees, such as Wellingtonia gigantea and the Baobab,—the former of which has been measured 116 feet in circumference.

95. The composition of the vascular bundles, in different parts of their course, varies. Thus, at the upper part, where they proceed from the leaves towards the centre, they contain spiral vessels, porous vessels with some cellular tissue, a few laticiferous vessels, and woody fibres resembling those of liber (fig. 112.) As the bundles descend, the spiral vessels disappear, then the porous vessels, and when they have reached the periphery, and have become incorporated with it, nothing but fibrous tissue, or pleurenchyma, remains, forming by its division a complicated anastomosis, or net-work. Thus, at the commencement the bundles are large, but as they descend they usually become more and more attenuated. In some instances, however, as in Ceroxylon Andicola, they increase at different parts of their course, probably by interstitial growth, and give rise to irregular swellings of the stem. This distension takes place occasionally at the base of the stem, as in Euterpe montana.

96. There are many herbaceous plants in this country, as Lilies, Grasses, &c., having endogenous stems, in which the course of the vascular bundles may occasionally be traced, but there are no British endogenous plants with permanent aerial woody stems. All the British trees are exogenous. Illustrations of endogenous stems must therefore be taken from trees of foreign countries. Palms furnish the best examples. In them the stem forms a cylinder of nearly uniform diameter throughout. The leaves are produced from a single terminal and central bud, called a *Phyllophor* or *Phyllogen*, (φύλλον, a leaf, and φορεῖν, to bear, and γεννάειν, to produce). Connected with the leaves are the vascular bundles, and the bases of the leaves remain attached to the outer part of the stem, surrounded by the mattulla or reticulum (¶ 57). While the leaves produced by one bud decay, another bud is developed in the centre in a similar manner. As the definite vascular bundles are produced, the stem acquires increased thickness, but it is arrested in its transverse diameter at a certain epoch. The bundles, although developed progressively, do not multiply indefinitely; and thus a Palm-stem seldom becomes of great diameter.

97. In consequence of this mode of formation, the outer part of a Palm-stem is the hardest and densest, and after acquiring a certain degree of solidity, it resists all further distension, and frequently becomes so hard as to resist the blow of a hatchet. It has been already stated, that in the exogenous stem, provision is made for unlimited extension laterally, by the development of indefinite bundles of woody

fibres and vessels, and the formation of a separable bark which can be thrown off; but in the endogenous stem there is no such provision. Hence, when the first formed part of the stem has increased to a certain amount, its progress is stopped by the hard indistensible outer fibrous covering; and the same thing takes place with the other parts in succession, till at length all have acquired a comparatively uniform size, as is seen in the coco-nut palm (fig. 115, 1). In consequence of the small lateral increase of Palm-stems, a woody twining plant does less injury to them than to trees of exogenous growth.

98. The growth of endogenous stems may be said to resemble the upward growth of Exogens by terminal buds only, for there is no cambium layer, and no peripherical increase. Hence, in Palms, the terminal shoot is developed, but there are no annular rings. The hardening of the stem depends, in all probability, partly on internal changes in the woody fibres, similar to what takes place in the heart-wood of Exogens. Occasionally, at the upper part of a palm-stem there is an appearance of zones, but it does not continue throughout the stem. From the absence of concentric circles, the age of a Palm cannot be estimated in the same way as an exogenous tree. The elongation, however, of each species of Palm is pretty regular, and by it an opinion may be formed of the age. The rings on the surface of the stem are not indicative of yearly growth.

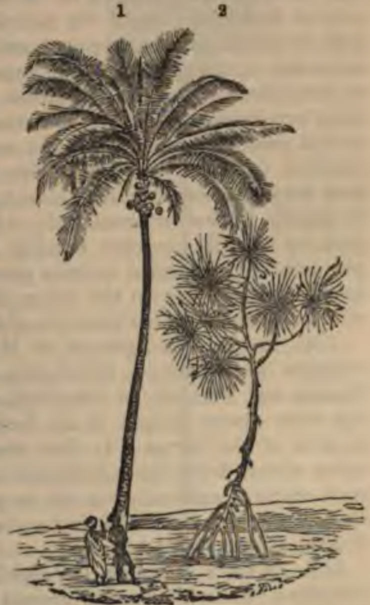

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Fig. 115.—Two endogenous or monocotyledonous trees, belonging to two different families. 1. Cocos nucifera, or coco-nut, belonging to the Palm family. 2. Pandanus odoratissimus, or screw-pine, belonging to Pandanaceæ. The first has a simple unbranched stem, with a cluster of leaves at the summit; the second has a branched stem, with numerous leafy clusters, and peculiar aerial roots, proceeding from different parts of the stem. Two human figures are given to indicate the height of the trees.

99. In Palms, there is in general no provision for lateral buds, and no branches are formed. Hence, destroying the central bud will kill the tree. In some Palms, however, as the Doom palm of Egypt (*Hyphæne thebaica*), the stem divides in a forked or dichotomous (δίχα, two ways, and τέμνειν, to cut) manner Gardner,

in his travels in Brazil, noticed a Palm in which the centre bud had been destroyed, and two side ones had been produced, so as to give it a forked appearance. Other plants with endogenous stems, also produce lateral buds. In fig. 115, 2, there is a representation of such a stem, in the case of the Screw-pine, (*Pandanus odoratissimus*), and examples are seen in Grasses, as the Bamboo, in Asparagus, Asphodels, and Dracænas. In these cases, the stem is conical, like that of Exogens, and the destruction of the terminal bud is not necessarily followed by the death of the plant. The development of lateral buds is accompanied often by an increased diameter of the stem. The famous Dracæna Draco, or Dragon tree of Orotava, in the Canary Islands, has a hollow stem capable of holding several men; and the fact of its living in this state is marked by Jussieu as an argument against the strict endogenous formation; for, if the centre were the youngest and newest part, its destruction would put an end to the existence of the tree, in the same way as the removal of the outer part of the wood would destroy an exogenous stem. The branches in such plants are formed on the same principle as the stems; but their fibres, when reaching the stem, do not proceed to the centre, but extend outside the previous layers, between them and the outer false bark (fig. 113 *l e*), and thus it is that they give rise to lateral increase. In Grasses, the stem or culm is usually hollow or fistular (fig. 111), in consequence of the outer part, by its rapid increase, causing the rupture and ultimate disappearance of the internal cellular portion. The fibres in some Grasses cross from one side to the other, forming partitions, as in Bamboo, which add much to the strength of the stem.

100. In many Endogenous or Monocotyledonous plants, the stem remains below ground, developing shoots which are simple, as in Banana and Plantain, or branched, as in Asparagus. In the former, the stem above ground is an herbaceous shoot, composed of the sheaths of the leaves. It dies after fruiting, and is succeeded by other shoots from the subterranean stem. The shoots or buds from such stems occasionally remain in part below ground in the form of bulbs, as in Lilies and Hyacinths; or corms, as in Tulips, Colchicum, Crocus, Gladiolus, and Arum.

101. In some instances, the aerial stem has the usual endogenous structure, while the under-ground stem has the vascular bundles developed in the form of wedges, with cellular tissue in the centre, thus resembling some Exogens. This structure has been remarked in the Smilax or Sarsaparilla family. Lindley calls these plants *Dictyogens* (δίκτυον, a net), from their netted leaves, a character by which they differ from other Endogens. Henfrey holds that the ring of woody fibres in Tamus and Smilax, is merely an alteration of the parenchymatous cells of the periphery, and is not produced, as some have supposed, in the same way as the zones of Dicotyledons. He considers

this ring as probably analogous to the liber, and not to the indefinite vascular bundles of Exogenous stems.

Acrogenous or Acotyledonous Stem.

102. This stem, in its general external aspect, resembles that of Endogens. It is unbranched, usually of small, nearly uniform diameter, and produces leaves at its summit. It is easily distinguished by its internal structure. Tree Ferns furnish the best example of this kind of stem. In them it is denominated a *Stipe*, or a *Rachis*, and often attains the height of 120 feet (fig. 116). A transverse section of the stem (fig. 117) exhibits a circle of vascular tissue composed of masses, *z l*, of various forms and sizes, situated near the circumference; the centre, *m*, being either hollow or formed of cellular tissue. On the outside of the vascular circle, cells exist, *p*, covered by an epidermal layer or cellular integument, *e*, often of hard and dense consistence, formed originally by the bases of the leaves, which remain for a long time attached to the stem.

103. The vascular bundles are formed *simultaneously*, and not progressively as in the stem already noticed; and additions are always made in an upward direction. The stem then is formed by additions to the summit, and by the elongation of vessels already formed; hence the name *Acrogenous* (ἄκρος, summit). The leaves unite by their bases to form the stem, and the arrangement of their vessels is traced into it. The vascular system is of greater density than the rest of the tissue, and is usually distinguished by the dark colour of the pleurenchyma

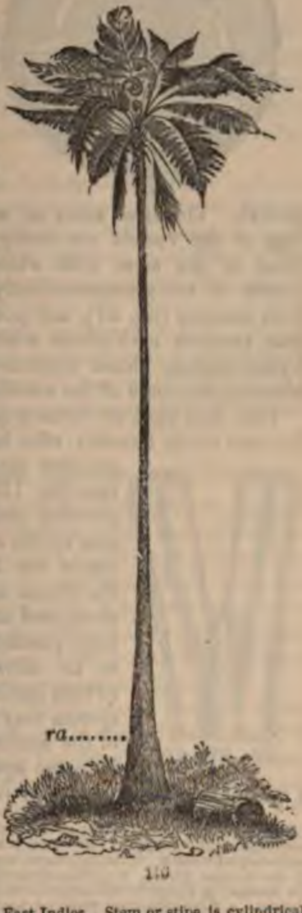

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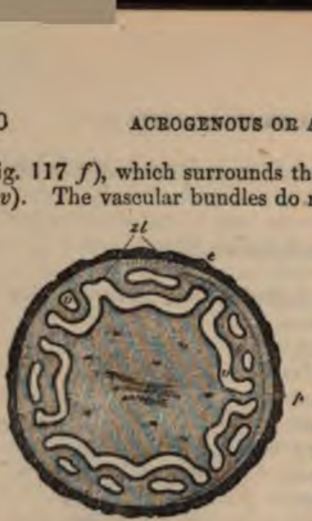
Fig. 116.—Tree fern (*Alsophila perrotetiana*), of the East Indies. Stem or stipe is cylindrical, unbranched, and presents at its base, *r a*, a conical enlargement, formed by a mass of adventitious roots. The leaves are terminal, and in the young state are rolled up in a circinate manner.

(fig. 117 *f*), which surrounds the paler vessels in the centre (fig. 117 *v v*). The vascular bundles do not follow a straight course, but unite and separate, leaving spaces between them, similar to those seen in the liber of Exogens (fig. 101).



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104. The acrogenous stem in the young state is solid, but it frequently becomes hollow in the progress of growth, by the rupture and absorption of the walls of the cells in the centre. The bases of the leaves remain long attached, but ultimately fall off, leaving marked scars which are at first close together, but often separate afterwards by interstitial growth. On these scars or *cicatrices* (*cicatrix*, a wound), the markings of the vessels are easily seen, arranged in the same manner as those of the stem with which they are continuous. The vascular system of ferns consists chiefly of scalariform vessels (fig. 62), mixed with annular (fig. 57), and porous vessels (fig. 98 *ter*). There are no true tracheæ with fibres which can be unrolled. In the stems of Lycopodiaceæ, closed tracheæ or ducts (¶ 34) occur; and in Equisetaceæ, the rings of the annular vessels are closely united.

105. The stem of Ferns is generally of small diameter; it does not increase much laterally, after having been once formed, and it does not produce lateral buds. Sometimes it divides into two (fig. 118), by the formation of two buds at its growing point. This, however, is an actual division of the stem itself, and differs from the branching of the Exogenous and Endogenous stem. In the Ferns of this country, the stems usually creep along and under the ground, and the leaves which they produce die annually without giving origin to an elevated trunk. In the common Brake (*Pteris aquilina*), the arrangement of the vascular system may be seen by making a transverse section of the under-ground stem. The plant has received its name *aquilina*, from a supposed resemblance to a spread eagle, presented by the vessels when thus cut across

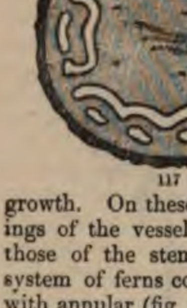

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Fig. 117.—Transverse section of the stem of a Tree fern (*Cyathea*). *m*, Cellular tissue, corresponding to pith, occupying the central part. *z l*, Vascular circle composed of numerous irregularly-formed masses. *f*, Dark-coloured woody or prosenchymatous fibres, forming the borders of the vascular masses. *v v*, Pale-coloured vessels, chiefly scalariform, occupying the centre of the masses. *p*, Parenchymatous or cellular external zone, often communicating with the central portion. *e*, Hard epidermal envelope, occupying the place of the bark.

Fig. 118.—Vertical section of part of the forked stem or stipe of Alsophila perrotetiana. *m*, Cellular central portion. *z l*, *z l*, Vascular zone, consisting of woody fibres and scalariform vessels. The forking is caused by an actual division of the stipe.

106. In some *Thallogens*, which have been noticed as being stemless, the thallus or frond is supported by a stalk, in which there are concentric circles, with divisions in the form of rays, and a sort of pith. These are all forms of cellular tissue, however, without any woody fibres. These appearances are presented by some large antarctic sea-weeds, species of D'Urvillea, and by some lichens, as Usnea.

107. There are thus three kinds of stems in the vegetable kingdom:—

1.—*Exogenous* or *Dicotyledonous*, having a separable bark; distinct concentric circles, composed of progressive indefinite vascular bundles, increasing at their periphery, the solidity diminishing from the centre towards the circumference; pith, enclosed in a longitudinal canal or medullary sheath, with cellular prolongations in the form of medullary rays.

2.—*Endogenous* or *Monocotyledonous*, having no separable bark; no distinct concentric circles; vascular bundles progressive and definite, not increasing at their periphery, the solidity diminishing from the circumference to the centre; no distinct pith, no medullary sheath nor medullary rays, the cellular tissue being interposed between the vascular bundles.

3.—*Acrogenous* or *Acotyledonous*, having no separable bark; no concentric circles; vascular bundles simultaneous, forming an irregular circle; additions being made to the summit; no distinct pith, no medullary sheath nor medullary rays; conspicuous scars left by the bases of the leaves.

Formation of the different parts of Stems, and their special Functions.

108. The stem bears the buds from which branches, leaves, and flowers are developed; it exposes these organs to the atmosphere and light, conveys fluids and air, and receives secretions. Stems vary much in their size, both as regards height and diameter. Some oaks in Britain have a height of nearly 120 feet; forest trees in France have attained to 120 and 130 feet, and in America even to 450 feet. Some Palms attain a height of 200 feet. The trunks of the Baobab and Wellingtonia are sometimes 30 feet or more in diameter.

109. The *pith*, in its early state (fig. 94 *p*), is of a greenish colour, and contains much fluid, which is employed in the nourishment of the young plant. After serving a temporary nutritive purpose, it becomes dry, or disappears by rupture and absorption of the walls of the cells which enter into its composition. The *medullary sheath*, which is the first formed vascular layer (fig. 96 *e m*), keeps up a connection between the central parts of the stem and the leaves, by means of spiral vessels, which seem to be concerned partly in the conveyance of air. This is the only part of a Dicotyledonous stem in which these vessels ordinarily occur. The *medullary rays* (fig. 97 *r m*), preserve a com-

munication between the bark and the pith. The cells of which they are composed, are concerned in the production of leaf buds, and they assist in the elaboration and conveyance of secretions. They have a direct connection with the *cambium cells* (fig. 97 *c*), or the cells between the wood and bark, whose function is to aid in the formation of new wood. The *bark* (fig. 97 *f c*, *e c*, *p*), protects the tender wood, conveys the elaborated sap downwards from the leaves, and is the part in which many valuable products, such as gum, tannin, and bitter principles, are formed and deposited. The *vascular bundles* (fig. 97 *f l*, *v p*), convey the sap from the root to the leaves. This function is carried on during the life of the plant by the annular vessels and the porous vessels, as well as other kinds of spurious fibro-vascular tissue; but in the woody fibres it ceases at a certain epoch, in consequence of the tubes being filled up by secondary deposits, so as to form the perfect wood, which gives strength and stability to the stem.

110. Considerable differences of opinion have arisen on the subject of the formation of wood. All agree that it cannot be properly formed unless the leaves are exposed to air and light, but physiologists differ as to its mode of deposition. Some say that it is deposited in a horizontal, others, in a vertical direction. There seems to be no doubt, that the cambium cells perform an important part in the formation of wood, and that their activity depends on the proper development of leaves. These formative cells, although most easily detected in exogenous stems, are also present in the other forms ot stems which have been described. In Monocotyledonous stems these cambium cells are situated in the centre of the bundles, and are concerned in the formation of the vascular tissue surrounding them. In woody Acotyledonous stems, as in Tree-ferns, these cells surround the vascular bundles. After a certain time the cambium zones in these stems become woody, and then the vascular bundles only grow at their extremity by means of unchanged cambium cells. In both these kinds of stems the vascular bundles are limited, and the stems can only increase laterally by ramifying or dividing dichotomously, as in Dracæna and some Tree-ferns.

111. The early physiologists made experiments on exogenous stems, as being most easily procured. They espoused the *horizontal* theory of deposition, and disputed as to the formation of cambium; some maintaining that it was formed by the cells of the bark; others, by the central cells of the stem; and others, by both united. Duhamel, by putting silver plates between the bark and wood; and Dr. Hope, by detaching portions of bark, endeavoured to show that the bark alone was concerned in the formation of wood; while Decandolle and others were led to the conclusion, that both were concerned in the process of forming cambium, by means of which a layer of liber and a layer of wood was annually produced.

112. Knight espoused what is called the *vertical* theory, considering the wood as developed in a downward direction by the leaves, and in this view he is supported by Petit-Thouars and Gaudichaud. These physiologists maintain that there are two vascular systems in plants, an ascending and descending; the one connected with the leaf formation, or the spiral vessels; the other connected with the production of roots, or the woody fibres—the cellular tissue being more especially concerned in horizontal development. Every bud is thus, according to them, an embryo plant fixed on the stem, sending leaves upwards, and roots downwards. In Palms, Dracænas, and other Endogenous stems, the peculiar manner in which the woody fibres interlace (fig. 114, 2), favours the opinion that they are developed like roots, by additions to their extremities; and this is also strengthened by the formation of adventitious or aerial roots, which burst through different parts of the stem in Screw-pines (fig. 115, 2), in the Banyan, and in the Fig tribe in general. In Vellozias and Tree Ferns, the surface of the stem is often covered with thin roots, protruding at various parts, and becoming so incorporated with the stem as to appear to be a part of it. In the Tree Fern, represented in fig. 116, the lower part of the stem is enlarged in a remarkable degree by these fibres, so as to give it a conical form. In exogenous stems, when ligatures are put round the stem, and when portions of bark are removed, a swelling takes place above the parts where the injury has been inflicted, thus apparently proving that the new matter is developed from above downwards.

113. Gaudichaud endeavours to account for various anomalous forms of stems (figs. 105—108), by considering them as depending on the arrangement of the leaves, and on the mode in which the woody fibres are sent down from them. Thus, the four secondary masses surrounding the central one in the stem of Calycanthus floridus, are traced to four vascular bundles from the leaves, penetrating the cellular tissue of the bark, distinct from the central wood and from each other, except at the nodes, where the cross bundles unite them so as to form a ring round the central mass. New fibres are formed on the inner side of these bundles, and by degrees they assume a crescentic shape, while the horns of the crescent ultimately unite on the outer side (centrifugally), and enclose a portion of the bark, which thus forms a kind of spurious excentric pith, with numerous woody layers on the inside, and a smaller number on the outside. Again, in Brazilian Sapindaceæ (fig. 106), with five, seven, nine, or ten woody masses, the same thing is said to occur, with this difference, that the pith of each of the masses is derived from the original medullary centre, portions of which are enclosed by the vascular bundles in a centripetal manner, or from without, inwards.

114. Treviranus states that the fibrous and vascular bundles descending from the leaves, are destined in general to unite around a

common centre, but that they retain a certain degree of independence, and may be developed separately in some instances, giving rise to anomalous fasciculated stems.

115. Gardner, from an examination of Brazilian Palms, adopts the vertical theory, and Lindley also supports it. It is strongly opposed by Schleiden, Mirbel, Naudin, Henfrey, and Trecul, who consider the development of the vascular bundles, as proceeding from below upwards; in Dicotyledons, by peripherical production of woody and vascular tissue from cambium cells; and in Monocotyledons, by a definite formation of woody and vascular bundles by means of terminal buds; the hardening of the stem depending on the interstitial changes which take place afterwards in the woody fibres.

116. A consideration of all the observations made on the formation of woody stems, leads apparently to the conclusion, that there is an ascending and descending axis in plants, and that each plant consists of one or more individuals, or *phytons* (φυτὸν, a plant), as they are called by Gaudichaud and others, having both axes developed; the Exogenous stem being formed by the original formation of two opposite phytons the Endogenous by one: and that woody fibres are produced from cells, which, in Exogens, are formed annually between the wood and bark, as cambium cells; and, in Endogens, are developed in the internal parts of the stem. Proof seems, however, still wanting of the direction in which the development of wood takes place in the former; while, in the latter, observations seem to be in favour of a vertical formation, or of additions of woody fibre being made in a downward direction, as in roots, thus following the course of the descending elaborated sap.[*] Mirbel, from his investigations respecting the growth of the Date, believes that its fibres extend from below upward. He states, that at the summit of Monocotyledonous plants a mass of cellular tissue is produced, called a phyllophor, and that the formation of a vascular system in the plant precedes the development of the leaves.[†] Trecul has also shown that woody fibres in Dicotyledonous plants are not necessarily dependent on the presence of leaves, since ligneous tissue has been developed in the centre of portions of stems from which the bark had been removed. He believes that local increase depends on local action, that ligneous tissue is locally developed from previously existing cells, and that there is no evidence of fibres descending from the leaves or buds.[‡]

117. All physiologists agree in believing that the formation of woody matter depends mainly on the functions of the leaves being

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[*] For full details relative to the formation of wood, see Gaudichaud, Recherches sur l'Organographie, &c., Paris, 1841; Mirbel, Annales des Sciences Naturelles, 2d series tom. xx., &c.; Naudin, do., 3d series, tom. i.; Henfrey, Annals of Natural History, 2d series, vol i.

[†] Mirbel, Recherches sur la Structure du Datiert.—Annales des Sciences, Nat. 2d series, xx. 5.

[‡] Trécul, Sur l'accroissement en diametre des Vegetaux dicotylédonés ligneux.—Annales des Sc. Nat. 3d series, xvii.

carried on properly, and this can only be effected by exposure to air and light. The more vigorously the plant grows, the better is the wood produced. Experiments made in the British dockyards proved that those oaks which had formed the thickest zones, yielded the best timber. Barlow's experiments at Woolwich, showed that a plank of quick-grown oak, bore a greater weight than a similar plank of slow-grown oak.

118. In order that trees may grow well, and that timber may be properly formed, great care should be taken in planting at proper distances and in soil fitted for the trees. Firs ought to be planted from 6 to 8 feet apart, and hardwood trees for a permanent plantation, 28 feet distant, the spaces being filled up with larch, spruce, or Scotch fir, according to soil and situation. Hardwood is of no value till it has attained some age, while larch and spruce may be applied to use in ten or twelve years; and thus judicious thinning may be practised. When trees are set too close, their leaves are interrupted in their functions; many of them fall off, leaving the stems bare; the wood is imperfectly formed, and the roots are not sent out vigorously. When such plantations are allowed to grow without being thinned, the trees are *drawn up* without having a hold of the ground; and when a portion of them is subsequently removed, the remainder is easily blown over by the wind. In thick plantations, it is only on the trees next the outside, where the leaves and branches are freely formed, that the wood and roots are properly developed. When a tree is fully exposed to air and light on one side only, it is frequently found that the woody zones on that side are largest. When trees are judiciously planted, there is a great saving both in the original outlay and in the subsequent treatment. Pruning or the shortening of branches and the removal of superfluous ones ought to be cautiously practised It is only applicable to young branches and twigs, and is had recourse to chiefly in the case of fruit-trees when the object is to make the plants produce flowers and fruit. If forest trees are properly planted and thinned, little pruning is required.

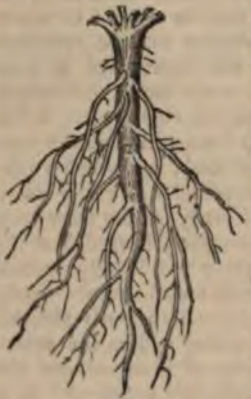
ROOT OR DESCENDING AXIS.

Structure of Roots.

119. In the young state there is no distinction between stem and root, as regards structure; both being cellular, and an extension of each other in opposite directions. In stemless plants, as Thallogens, the root remains in a cellular state throughout the life of the plants. The root is afterwards distinguished from the stem, by the want of a provision for the development of leaf-buds, and by increasing from above downwards. Some plants, however, as the Moutan Pæony, the

Plum-tree, Pyrus japonica, and especially Anemone japonica, have a power of forming buds on their roots. The last-mentioned plant developes these buds on every part of its extensively ramifying roots, which may be chopped into numerous pieces, each capable of giving rise to a new plant. The part where the stem and root unite is the *collum* or *neck*. In woody plants, the fibres of the stem descend into the roots, and there is a similar internal arrangement of woody layers, as is seen in the stem itself.

120. Roots are usually subterranean and colourless. Externally, they have a cellular epidermal covering of a delicate texture, sometimes called *epiblema* (¶ 47), in which no stomata exist. Their internal structure consists partly of cells, and partly of vascular bundles, in which there are no vessels with fibres which can be unrolled. Roots do not exhibit true pith, nor a medullary sheath. The axis of the root gives off branches which divide into radicles or fibrils (fig. 119), the extremities of which are composed of loose sponge-like cellular tissue, and are called *spongioles* or *spongelets*. Over these a very thin layer of cells is extended, called, by Trecul, a *Pileorhiza* (πῖλος, a cap, and ῥίζα, a root). This sometimes becomes thickened, and separates in the form of a cup, as in Screw-pines (fig. 115, 2), and in Lycopodiums. Occasionally the extremities of roots are enclosed in a sheath, or *ampulla*, as in Lemna. Cellular papillæ, and hairs are often seen in roots (fig. 77), but no true leaves. These hairs consist of simple elongated cells which occur singly, and appear to serve the purpose of absorption. Roots do not grow throughout the whole length like stems, but by additions to their extremities, which are constantly renewed, so that the minute fibrils serve only a temporary purpose, and represent deciduous leaves. Schleiden has, therefore, observed that the tissue at the extremities of roots is older and more dense than that immediately below it.



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121. Roots, in some instances, in place of being subterranean, become aerial. Such roots occur in plants called *Epiphytes*, or air-plants (ἐπὶ, upon, and φυτὸν, a plant, from growing on other plants), as in Orchidaceæ; also in the Screw-pine (fig. 115, 2), the Banyan (Ficus indica), and many other species of Ficus, where they assist in supporting the stem and branches, and have been called *adventitious* or

Fig. 119.—Tapering root of Malva rotundifolia, giving off branches and fibrils.

abnormal. In Screw-pines, these aerial roots follow a spiral order of development. In Mangrove trees, they often form the entire support of the stem, which has decayed at its lower part. The name of adventitious has also been applied to those roots which are formed where portions of stems and branches, as of the Willow and Poplar, are planted in moist soil. They appear first as cellular projections, into which the fibres of the stem are prolonged, and by some are said to proceed from lenticels (¶ 63). They frequently arise from points where the epidermis has been injured. A Screw-pine in the palm-house of the Edinburgh Botanic Garden, had one of its branches injured close to its union with the stem. This branch was at the distance of several feet above the part where the aerial roots were in the course of formation. At the part, however, where the injury had been inflicted, a root soon appeared, which extended rapidly to the earth, and now the branch is firmly supported.

122. Green-coloured aerial roots are frequently met with in endogenous plants. Such roots possess stomata. In the Ivy, root-like processes are produced from the stem, by means of which it attaches itself to trees, rocks, and walls. Those processes are subservient to the purposes of support rather than nutrition. In parasites, or plants which derive nourishment from other plants, such as Dodder (*Cuscuta*), roots are sometimes produced in the form of *suckers*, which enter into the cellular tissue of the plant preyed upon.

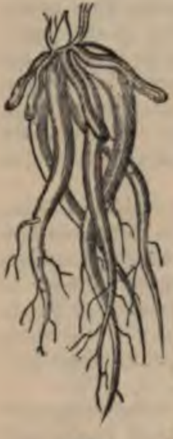
123. When roots have been exposed to the air for some time, they occasionally assume the functions of stems, losing their fibrils, and developing abnormal buds. Duhamel proved this experimentally, by causing the branches of a willow to take root while attached to the stem, and ultimately raising the natural roots into the air.

Forms of Roots.

124. The forms of roots depend upon the mode in which the axis descends and branches. When the central axis goes deep into the ground in a tapering manner, without dividing, a *tap-root* is produced (fig. 119). This kind of root is sometimes shortened, and becomes succulent, forming the *conical* root of carrot, or the *fusiform*, or spindle-shaped root of radish, or the *napiform* root of turnip; or it ends abruptly, thus constituting the *præmorse* (*præmorsus*, bitten) root of Scabiosa succisa; or is *twisted*, as in the *contorted* root of Bistort.

125. When the descending axis is very short, and at once divides into thin, nearly equal fibrils, the root is called *fibrous*, as in many grasses; when the fibrils become short and succulent, the root is *fasciculated*, as in Ranunculus Ficaria and Asphodelus luteus (fig. 120); when the succulent fibrils are of uniform size, and arranged like coral, the root is *coralline*, as in Corallorhiza innata; when some of the

fibrils are developed in the form of tubercules containing starchy matter, as in Orchis, the root is *tubercular* (fig. 121); when the fibrils enlarge in certain parts only, the root is *nodulose*, as in Spiræa Filipendula (fig. 122), or *moniliform*, as in Pelargonium triste (fig. 123), or *annulated*, as in Ipecacuanha.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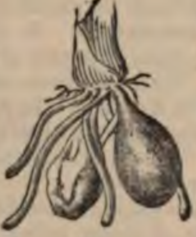
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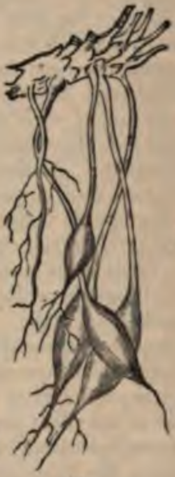
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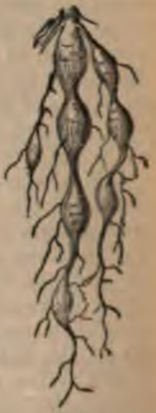
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126. **Root of Dicotyledonous or Exogenous Plants.**—In these plants the root in its early state, or the *radicle* as it is then called, is a prolongation of the stem, and elongates directly by its extremity. It then continues to grow in a simple or branched state (fig. 119). From this mode of root development, these plants have been called *Exorhizal* (ἔξω, outwards, and ῥίζα, a root), by Richard. In their after progress, these roots follow the arrangement seen in the woody part of the stem. In some cases, as in the Walnut and Horse-chestnut, there is a prolongation of the pith into the root to a certain extent.

127. **Root of Monocotyledonous or Endogenous Plants.**—In these plants the young root or radicle pierces the lower part of the axis (fig. 124 *r*), is covered with a cellular sheath, *c*, and gives rise to numerous fibrils, $r' \; r' \; r' \; r'$, which are similarly developed. These plants are therefore called by Richard, *Endorhizal* (ἔνδον, within); and the sheath is denominated *Coleorhiza* (κολεός, a sheath). In their after

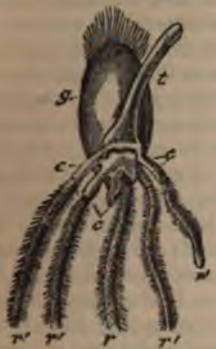
Fig. 120.—Fasciculated root of Asphodelus luteus.

Fig. 121.—Tubercular root of Orchis. Several of the radical fibres retain their cylindrical form, while two are tubercules containing starchy matter.

Fig. 122.—Nodulose root of Spiræa Filipendula.

Fig. 123.—Moniliform root of Pelargonium triste.

progress, they usually retain their compound character, consisting of fibrils, most of which often remain unbranched (figs. 120, 121). The first-formed roots which surround the axis, if the plant is perennial, gradually die, and others are produced in succession farther from the central axis. In Endogenous roots, the same structure is observed as in the stem. Thus, fig. 125 represents a section of a Palm root, composed of cellular tissue, porous vessels, *v p*, scalariform vessels, *v s*, fibrous or woody tissue, *f*, and laticiferous vessels, *l*. Roots are pushed out from various parts of the stems of many Palms, and ultimately appear as part of the external integument.



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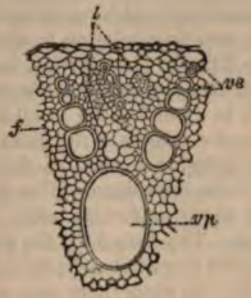

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128. **Root of Acotyledonous or Acrogenous Plants.**—In these plants, the young root is a development of superficial cells from no fixed point, and they have been called *Heterorhizal* (ἕτερος, diverse). In their subsequent progress, these roots present appearances similar to those seen in the stem. They frequently appear in the form of fibres on the outer part of the stem, giving rise, by their accumulation at the base, to the conical appearance represented in fig. 116 *r a*.

Functions of Roots.

129. Roots fix the plant, either in the soil or by attachment to other bodies. They absorb nourishment by a process of imbibition or endosmose (¶ 27), through their spongioles or cellular extremities.

Fig. 124.—Grain of wheat germinating. *g*, The mass of the grain. *t*, The young stem beginning to shoot upwards. *r*, The principal root of axis. *r′ r′ r′ r′*, Lateral roots, covered like the preceding, with small hairs or threads. *c c c*, Coleorhiza or sheath, with which each of the roots is covered at its base, while piercing the superficial layer of the embryo.

Fig. 125.—Transverse section of part of the root of a Palm (*Diplothemium maritimum*), to show the mode in which the cells and vessels are arranged. *v p*, Large porous vessels situated in the interior. *v s*, Scalariform vessels more external, and becoming smaller the farther they are from the centre. *f*, Fibrous tissue, or elongated cells, accompanying the vessels. *l*, Groups of laticiferous vessels of different sizes, the larger being inside.

The experiment of Duhamel and Senebier, conducted by inserting at one time the minute fibrils alone into fluid, and at another, the axis of the root alone, showed clearly that the cellular extremities were the chief absorbing parts of the roots. Hence the importance, in transplanting large trees, of cutting the roots some time before, in order that they may form young fibrils and spongelets, which are then easily taken up in an uninjured condition, ready to absorb nourishment.

130. The elongation of the roots by their extremities, enables them to accommodate themselves to the soil, and allows the spongioles to extend deeply without being injured. Roots in their lateral extension, bear usually a relation to the horizontal spreading of the branches, so as to fix the plant firmly, and to allow fluid nutritive substances to reach the spongioles more easily. It is of importance to permit the roots to extend easily in all directions. By restricting or cutting the roots, the growth of the plant is to a certain degree prevented, although it is sometimes made to flower and bear fruit sooner than it would otherwise have done. The system of restrictive potting, formerly practised in green-houses, often destroyed the natural appearance of the plants. The roots filled the pots completely, and even raised the plants in such a way as to make the upper part of the root appear above the soil.

131. To roots there are sometimes attached reservoirs of nourishment, in the form of tubercules, containing starch and gum (fig. 121), which are applied to the nourishment of the young plant. These are seen in the Dahlia and in terrestrial Orchids. In epiphytic Orchids, on the other hand, the roots are aerial, and the stems are much developed, forming pseudo-bulbs. Upon the roots of Spondias tuberosa there exist round black-coloured tubercules, about eight inches in diameter, consisting internally of a white cellular substance, which is full of water. These tubercules seem to be intended to supply water to the tree during the dry season. They are often dug by travellers, each of them yielding about a pint of fluid of excellent quality.

132. Roots also give off certain excretions, which differ in different species. These are given off by a process of exosmose (¶ 27), and consist both of organic and inorganic matter. They were examined by Macaire and Decandolle, and at one time they were thought to be injurious to the plant, and by their accumulation to cause its deterioration. It was also supposed, that while they were prejudicial to the species of plant which yielded them, they were not so to others, and that hence a rotation of crops was necessary. Daubeny and Gyde have found by experiment, that these excretions are not injurious, and it is now shown, that the necessity for rotation depends on the want of certain nutritive matters in the soil.* In very rich and fertile land, the same crop may be grown successively for many years.

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* This subject is considered when the sources whence plants derive their nourishment are treated of. page 121.

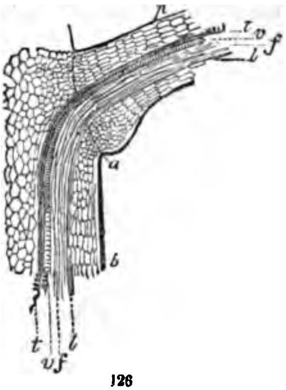
LEAVES AND THEIR APPENDAGES.

Structure of Leaves.

133. Leaves are expansions of the bark, developed in a symmetrical manner, as lateral appendages of the stem, and having a connection with the internal part of the ascending axis. They appear at first as small projections of cellular tissue, continuous with the bark, and closely applied to each other. In the early stages of their development they are undivided. These cellular papillæ, from which they derive their origin, gradually expand in various ways, acquire vascular tissue, and ultimately assume their permanent form and position on the axis. They may be divided into *aerial* and *submerged* leaves, the former being produced in the air, and the latter under water.

134. **Aerial Leaves.**—These leaves consist of vascular tissue in the form of *veins*, *ribs*, or *nerves*, of cellular tissue or *parenchyma* filling up the interstices between the veins, and of an *epidermal* covering.

135. The **Vascular System** of the leaf is continuous with that of the stem, those vessels which occupy the internal part of the stem becoming superior in the leaf, while the more external become inferior. Thus, in the upper part of the leaf, which may represent the woody layers, there are spiral vessels (fig. 126 *t*), annular, reticulated or porous vessels, *v*, and woody fibres, *f*; whilst in the lower side, which may represent the bark, there are laticiferous vessels and fibres, resembling those of liber, *l*. There are usually two layers of fibro-vascular tissue in the leaf, which may be separated by maceration. They may be seen in what are called *skeleton leaves*, in which the cellular part is removed, and the fibro-vascular left. The vascular system of the leaf is distributed through the cellular tissue in the form of simple or branching veins.



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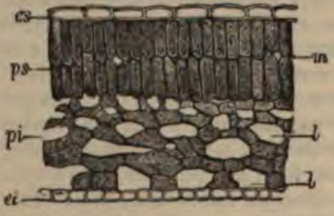
136. The **Epidermis** (fig. 127 *e s*, *e i*), composed of cells more or less compressed, has usually a different structure and aspect on the two surfaces of the leaf. It is chiefly on the epidermis of the lower surface (fig. 128 *e i*), that stomata, *s s*, are produced, occupying spaces between the veins, and it is there also that hairs usually occur. In

Fig. 126.—Bundle of fibro-vascular tissue, passing from a branch, *b*, into a petiole, *p*. The vessels are first vertical, then nearly horizontal, but they continue to retain their relative position. Changes take place in the size of the cells at the articulation *a*. *t t*, Tracheæ, in which the fibre can be unrolled. *v v*, Annular vessels. *f f*, Woody fibres. *l l*, Cortical fibres, or fibres of liber.

these respects, the lower epidermis resembles the outer bark of young stems, with which it may be said to correspond. The lower epidermis is often of a dull or pale-green colour, soft, and easily detached. The upper epidermis (figs. 127 and 128 *e s*) is frequently smooth and shining, and sometimes becomes very hard and dense. Many tropical plants present on the upper surface of their leaves several layers of compressed epidermal cells. These appear to be essential for the preservation of moisture in the leaf. In leaves which float upon the surface of water, as those of the water-lily, the upper epidermis alone possesses stomata (¶ 56). On removing a strip of epidermis, part of the parietes of the cells below is often detached in the form of a green net-work (fig. 129 *p p*), and on examination under the microscope, the stomata, *s s*, are seen communicating with colourless spaces, *l l l*, surrounded by green matter.



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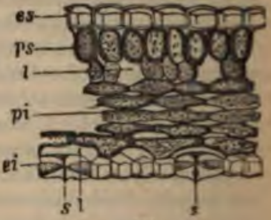

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137. The **Parenchyma** of the leaf is the cellular tissue surrounding the vessels, and enclosed within the epidermis (fig. 127 *ps*, *pi*). It has sometimes received the names of *Diachyma* (διὰ, in the midst, and χῦμα, tissue), or *Mesophyllum* (μέσος, middle, and φύλλον, a leaf), or *Diploë*, (διπλοΐς, a covering). It is formed of two distinct series of cells, each containing chlorophylle or green-coloured granules, but differing in their form and arrangement. This may be seen on making a vertical section of a leaf, as in fig. 127. Below the epidermis of the upper side of the leaf, there are one or two layers of oblong blunt cells, placed perpendicularly to the surface (fig. 127 *p s*), and

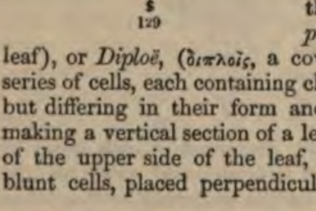

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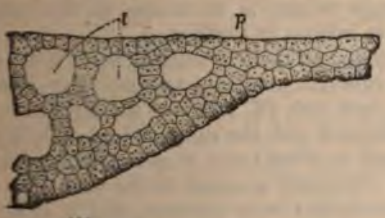
Fig. 127.—Thin vertical section of the leaf of a Lily, highly magnified. *e s*, Epidermis of upper pagina or surface. *e i*, Epidermis of lower surface. *p s*, Parenchyma of upper portion of the leaf, composed of close vertically-placed cells. *p i*, Parenchyma of lower portion, composed of loose horizontal cells. *m*, Intercellular passages. *l l*, Lacunæ.

Fig. 128.—Similar section of the leaf of Balsam. The letters denote the same parts as in fig. 127. *s s*, Stomata.

Fig. 129.—Strip of the lower epidermis, *e e*, of the leaf of Balsam, showing a net-work formed by a portion of the parenchyma below, *p p*, being detached. The spaces of the net are lacunæ, *l l l*, often corresponding to stomata, *s s*.

applied so closely to each other as to leave only small intercellular spaces (fig. 127 *m*), except when stomata happen to be present. On the under side of the leaf, the cells are irregular, often branched, and are arranged more or less horizontally (fig. 127 *p i*), leaving cavities between them, *l l*, which often communicate with stomata (fig. 128 *s s*). On this account the tissue has received the name of *cavernous*. The form and arrangement of the cells, however, depend much on the nature of the plant, and its exposure to light and air. Sometimes the arrangement of the cells on both sides of the leaf is similar, as occurs in leaves which have their edges presented to the sky. In very succulent plants, the cells form a compact mass, and those in the centre are often colourless. In some cases the cellular tissue is deficient at certain points, giving rise to distinct holes in the leaf, as in Monstera pertusa. In Victoria regia perforations in the leaf seem to be subservient to the purposes of nutrition, in permitting the air collected beneath the large expanded leaf to escape, and so allowing its under surface to be brought into immediate contact with the water.

138. **Submerged Leaves.**—Leaves which are developed under water differ in structure from aerial leaves. They have usually no fibro-vascular system, but consist of a congeries of cells which sometimes become elongated and compressed so as to resemble veins. They have a layer of compact cells on their surface (fig. 130 *p*), but no true epidermis, and no stomata. The internal structure consists of cells, disposed irregularly, and sometimes leaving spaces which are filled with air for the purpose of floating the leaf (fig. 130 *l*). When exposed to the air, these leaves easily part with their moisture, and become shrivelled and dry. In some instances there is only a net-work of filamentous-like cells formed, the spaces between which are not filled with parenchyma, giving a peculiar skeleton appearance to the leaf, as in Hydrogeton or Ouvirandra fenestralis (fig. 131). Such a leaf has been called *fenestrate* (*fenestra*, a window).



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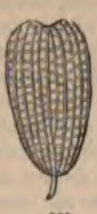

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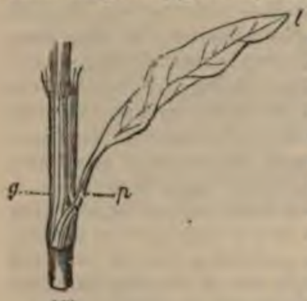
Fig. 130.—Perpendicular section through a small portion of the submerged leaf of Potamogeton perfoliatus. *p*, Parenchyma. *l*, Lacunæ.

Fig. 131.—Fenestrate leaf of Ouvirandra fenestralis, composed of vascular tissue, without intervening cellular tissue or diachyma.

139. A leaf, in general, whether aerial or submerged, consists of a flat expanded portion (fig. 132 *l*), called the *blade*, *limb*, or *laminar merithal*, (μέρος, a part, and θαλλός, a frond), of a narrower portion called the *petiole*, (*petiolus*, a little foot or stalk), *stalk*, or *petiolary merithal* (fig. 132 *p*), and sometimes of a portion at the base of the petiole, which forms a *sheath* or *vagina* (fig. 132 *g*), or is developed in the form of leaflets, called *stipules* (fig. 191 *s*). The sheathing portion or *vaginal merithal* is sometimes incorporated with the stem, and has been called *Tigellary* (*tige*, Fr., a stem or stalk), by Gaudichaud. These portions are not always present. The sheathing, or stipulary portion, is frequently wanting, and occasionally only one of the other two is developed. When a leaf has a distinct stalk it is called *petiolate;* when it has none, it is *sessile* (*sessilis*, from *sedeo*, I sit). When sessile leaves embrace the stem, they are called *amplexicaul* (*amplexor*, I embrace, and *caulis*, a stem). The part of the leaf next the petiole or the axis is its *base*, while the opposite extremity is the *apex*. The surfaces of the leaf are called the *paginæ* (*pagina*, a flat page), and its edges or margins form the *circumscription* of the leaf. The leaf is usually horizontal, so that the upper pagina is directed towards the heavens, and the lower pagina towards the earth; but in many cases leaves are placed vertically, as in some Australian Acacias, Eucalypti, &c.; in other instances, as in Alströmeria, the leaf becomes twisted in its course, so that what is superior at one part becomes inferior at another.



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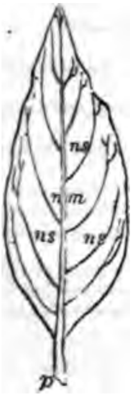
140. The upper angle formed by the leaf with the stem is called its *axil* (*axilla*, arm-pit), and everything arising at that point is called *axillary*. It is there that leaf-buds (¶ 180) are usually developed. The leaf is sometimes articulated with the stem, and when it falls off a *scar* or *cicatricula* remains; at other times it is continuous with it, and then decays gradually, while still attached to the axis. In their early state all leaves are continuous with the stem, and it is only in their after-growth that articulations are formed. When leaves fall off annually, they are called *deciduous;* when they remain for two or more years, they are *evergreen*. The laminar portion of a leaf is occasionally articulated with the petiole, as in the Orange (fig. 185), and a joint at times exists between the vaginal or stipulary portion and the petiole.

Fig. 132.—Leaf of Polygonum Hydropiper, with a portion of the stem bearing it. *l*, Limb lamina, or blade. *p*, Petiole or leaf-stalk. *g*, Sheath or vagina, embracing the stem, and terminated by a fringe.

Distribution of the Veins, or Venation of Leaves.

141. The distribution of the veins has been called *Venation*, sometimes *Nervation*. In most leaves this can be easily traced, but in the case of succulent plants, as Hoya, Agave, and Mesembryanthemum, the veins are obscure, and the leaves are said to be *Hidden-veined* (figs. 171, 172). In the lower tribes of plants, as sea-weeds, and in submerged leaves, there are no true veins, but only condensations of elongated cellular tissue, and the term *Veinless* (*avenia*) is applied. In an ordinary leaf, as that of Lilac or Chestnut, there is observed a central vein larger than the rest, called the *midrib* (fig 133 *m*); this gives off veins laterally (*primary veins*), *ns ns ns*, which either end in a curvature within the margin, as in Lilac (fig. 133), or go directly to the edge of the leaf, as in Oak and Chestnut (fig. 134). If they are curved, then external veins and marginal veinlets are interspersed through the parenchyma external to the curvature. There are also other veins of less extent (*costal veins*) given off by the midrib, and these give origin to small *veinlets*. In some cases, as Sycamore and Cinnamon, in place of there being only a single central rib, there are several which diverge from the part where the blade joins the petiole or stem. Thus, the primary veins give off secondary veins, and these in their turn give off tertiary veins, and so on, until a



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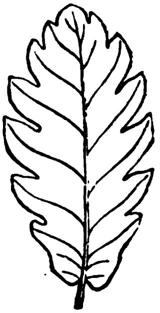

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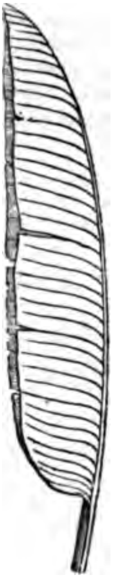

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Fig. 133.—Leaf of Belladonna. *p*, Petiole or leaf-stalk. *n m*, Midrib. *ns ns ns*, Primary veins, ending in curvatures at their extremities.

Fig. 134.—Leaf of Oak, pinnatifid or divided into lobes in a pinnate manner; feather-veined, the veins going directly to the margin.

Fig. 135.—Leaf of Banana, showing midrib and primary veins running parallel and in a curved manner to the margin. No reticulation. Plant monocotyledonous.

complete net-work of vessels is produced. To such a distribution of veins, the name of *Reticulated* or *Netted* venation has been applied.

142. In the leaves of some plants there exists a central rib or midrib, with veins running nearly parallel to it from the base to the apex of the leaf, as in grasses (fig. 194) and Fan palms; or with veins coming off from it throughout its whole course, and running parallel to each other in a straight or curved direction towards the margin of the leaf, as in Plantain and Banana (fig. 135). In these cases the veins are often united by cross veinlets, which do not, however, form an angular net-work. These are called *Parallel-veined.*

143. Leaves may thus be divided into two great classes, according to their venation—*Reticulated or netted leaves,* in which there is an angular net-work of vessels, as occurs generally in the leaves of exogenous or dicotyledonous plants; and *Parallel-veined,* in which the veins run in a straight or curved manner from base to apex, or from the midrib to the margin of leaf, and in which, if there is a union, it is effected by transverse veins which do not form an angular network. This kind of leaf occurs commonly in endogenous or monocotyledonous plants.

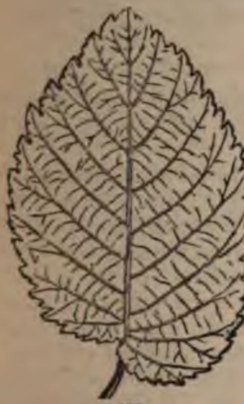
144.—TABULAR ARRANGEMENT OF VENATION.

A.—Reticulated Venation.
I. *Unicostate* (*unus*, one). A single rib or costa in the middle (midrib).
1. Primary veins coming off at different points of the midrib.
a. Veins ending in curvatures within the margin (fig. 133), and forming what have been called *true netted* leaves (Lilac).
b. Veins going directly to the margin (fig. 134), and forming *feather-veined* leaves (Oak and Chestnut).
2. Primary veins coming off along with the midrib (fig. 143) from the base of the leaf.
II. *Multicostate* (*multus*, many). More than one rib. In such cases there are frequently three (*tricostate*), as in fig. 162; or five (*quinquecostate*), as in fig. 158. Authors usually give to these leaves the general name of *costate*, or *ribbed.*
1. *Concostate* (*con*, together, *costa*, a rib). Ribs converging, running from base to apex in a curved manner, as in Cinnamon and Melastoma (fig. 158). There is occasionally an obscure rib running close to the edge of the leaf, and called intramarginal, as in the Myrtle.
2. *Discostate* (*dis*, separate). Ribs diverging or proceeding in a radiating manner; this is called radiating venation, and is seen in Sycamore, Vine, Geranium (figs. 144, 146).
B.—Parallel Venation.—The term parallel is not strictly applicable, for the veins often proceed in a radiating manner, but it is difficult to find a comprehensive term. This venation may be characterized as *not reticulated.*
I. Veins proceeding from midrib to margin, usually with convexity towards the midrib, as in Musa and Canna (fig. 135).
II. Veins proceeding from base to apex.
1. Veins more or less convergent (fig. 173), as in Iris, Lilies, Grasses (fig. 194).
2. Veins more or less divergent, as in Fan Palms.

To this may be added the venation common in Ferns where the veins divide in a forked manner. This venation has been called *Furcate* (*furca*, a fork).

Forms of Leaves.

145. Leaves have been divided into *simple* and *compound*. The former have no articulation beyond the point of their insertion on the stem, or consist of one piece only, which, however, may be variously divided (figs. 136, 137, 138, &c.). The latter have one or more articulations beyond the point of their insertion on the stem, or consist of one or more leaflets (*foliola*) separately attached to the petiole or leaf-stalk (fig. 141). In the earliest stage of growth all leaves are simple and undivided, and it is only during the subsequent development that divisions appear. The forms which the different kinds of simple and compound leaves assume, are traced to the character of the venation, and to the amount of parenchyma produced.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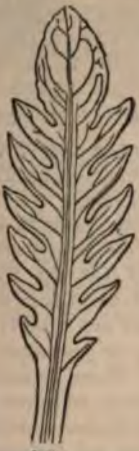
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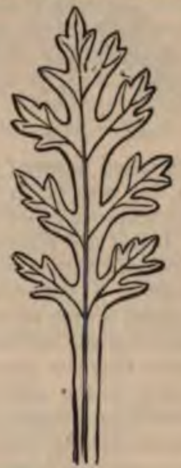
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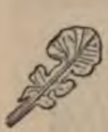
146. **Simple Leaves.**—When the parenchyma is developed symmetrically on each side of the midrib or stalk, the leaf is *equal* (fig. 149); if otherwise, the leaf is *unequal* or *oblique* (fig. 136), as in Begonia. If the margins are even and present no divisions, the leaf is *entire* (*integer*), as in figs. 149 and 150; if there are slight projections of cellular or vascular tissue beyond the margin, the leaf is not entire (fig. 136); when the projections are irregular and more or less pointed, the leaf is *dentate* or toothed (fig. 155); when they lie regularly over each other, like the teeth of a saw, the leaf is *serrate* (figs. 136, 154); when they are rounded, the leaf is *crenate* (fig. 159). If the divisions extend

Fig. 136.—Leaf of Ulmus effusa. Reticulated venation; primary veins going to the margin, which is serrated. Leaf unequal at the base.
Fig. 137.—Pinnatifid leaf of Valeriana dioica.
Fig. 138.—Bipinnatifid leaf of Papaver Argemone. Feather-veined.

more deeply than the margin, the leaf receives different names according to the nature of the segments: thus, when the divisions extend about half way down (figs. 134, 144), it is *cleft* (*fissus*), and its segments are called *fissures* (*fissura*, a cleft); when the divisions extend nearly to the base or to the midrib (fig. 170), the leaf is *partite*, and its segments are called *partitions*.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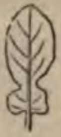
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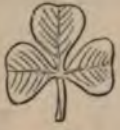
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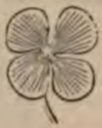
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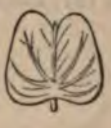
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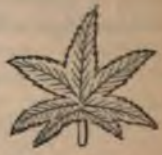
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147. These divisions take place in simple leaves exhibiting different kinds of venation, and thus give rise to marked forms. Thus, if they occur in a *feather-veined* leaf (fig. 137), it becomes either *pinnatifid* (*pinna*, a wing or leaflet, and *fissus*, cleft), when the segments extend to about the middle and are broad; or *pectinate* (*pecten*, a comb), when they are narrow; or *pinnatipartite*, when the divisions extend nearly to the midrib. These primary divisions may be again subdivided in a similar manner, and thus a *feather-veined* leaf will become *bipinnatifid* (fig. 138), or *bipinnatipartite*; and still further subdivisions give origin to *tripinnatifid* and *laciniated* leaves. If the divisions of a pinnatifid leaf are more or less triangular, and are pointed downwards towards the base, the extremity of the leaf being undivided and triangular, the leaf is *runcinate* (*runcina*, a large saw), as in the Dandelion. When the apex consists of a large rounded lobe, and the divisions, which are also more or less rounded, become gradually smaller towards the base (fig. 139), as in Barbarea, the leaf is called *lyrate*, from its resemblance to an ancient lyre.* When there is a concavity on each side of a leaf, so as to make it resemble a violin, as in Rumex pulcher (fig. 140), it is called *panduriform* (πανδοῦρα, fiddle).

148. The same kinds of divisions taking place in a simple leaf with *radiating* venation, give origin to the terms *lobed* or *cleft* (figs. 174, 146), when the divisions extend about half-way through the leaves: and thus they may be *three-lobed*, *five-lobed*, *seven-lobed*, *many-lobed*; or, *trifid*, *quinquefid*, *septemfid*, *multifid*, according to the number of

Fig. 139.—Lyrate leaf of Barbarea.
Fig. 140.—Panduriform, a fiddle-shaped leaf of Rumex pulcher.
Fig. 141.—Compound leaf; ternate, the leaflets being obcordate.
Fig. 142.—Compound leaf; quaternate, the leaflets being rotundate-cuneiform, or wedge-shaped with rounded apices.
Fig. 143.—Two-lobed leaf, somewhat cordate at the base, emarginate, and mucronate.
Fig. 144.—Palmate leaf, the divisions acute and serrated at their margins. Radiating venation.

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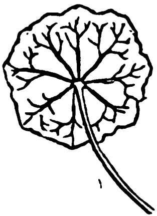
* Under the term lyrate, some include compound pinnate leaves in which the several pinnæ are united at the apex of the leaf, and the others become gradually smaller towards the base

divisions. The name of *palmate*, or *palmatifid* (fig. 144), is applied to leaves with radiating venation, in which there are several fissures united by a broad expansion of parenchyma, like the palm of the hand, as in Passion-flower and Rheum palmatum; while *digitate* (*digitus*, a finger), or *digitipartite*, includes leaves in which there are deeper partitions, five in number, like the fingers, as in Janipha; and *dissected* applies to leaves with radiating venation, having numerous narrow divisions, as in Geranium dissectum. When in a radiating leaf there are three primary partitions and two lateral ones spreading and forming divisions on their inner margin only, as in Helleborus (fig. 170), the leaf is called *pedate* or *pedatifid* (*pes*, a foot), from a fancied resemblance to the claw of a bird.

149. In all the instances already alluded to, the leaves have been considered as flat expansions in which the ribs or veins spread out on the same planes with the stalk. In some cases, however, the veins spread at right angles to the stalk. If they do so equally on all sides, and are united by parenchyma, so that the stalk occupies the centre (fig. 145), the leaf becomes *orbicular* (*orbis*, a circle), as in Hydrocotyle; if unequally, so that the stalk is not in the centre, the leaf is *peltate* (*pelta*, a buckler), as in the Castor oil plant (fig. 146). The edges or margins of orbicular and peltate leaves are often variously divided.

150. It has been observed that the order of the venation in the leaf bears a close analogy to the arrangement of the branches on the stem. That a certain unity so pervades vegetable organization, that the root, the stem, and the leaves may, in their ultimate arrangement, be regarded as being typical the one of the other. M'Cosh states, that the angles at which the veins are given off in the leaves are the same as those at which the branches come off from the stem. The angles as given by him vary from 30° to 70°.[*] It is impossible to notice all the forms of leaves without exceeding due limits. The following are enumerated as the most important. When the veins do not spread out, but run from the base to the apex with a narrow strip of parenchyma, the leaf is *linear* or



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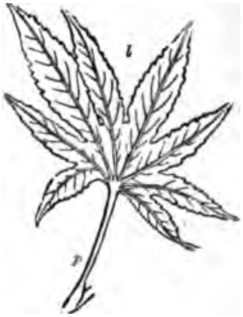

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Fig. 145.—Orbicular leaf of Hydrocotyle vulgaris. Radiating venation. *p*, Petiole. *l*, Lamina.

Fig. 146.—Peltate leaf of Ricinus communis, or Castor oil plant. Radiating venation. *p*, Petiole or leaf-stalk. *l*, Lamina or blade.

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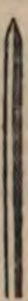
[*] M'Cosh on the plant morphologically considered. Proceed. of the Edin. Bot. Soc., July, 1851. Bot. Gazette, September, 1851.

acicular (fig. 147), as in Pines and Firs. When the veins diverge, those in the middle being longest, and the leaf tapering at each end (fig. 166), it becomes *lanceolate* (*lancea*, a spear). If the middle veins only exceed the others slightly, and the ends are convex, the leaf is either *rounded* (*rotundatus*), as in fig. 164, *elliptical* (fig. 162), *oval* (fig. 149), or *oblong* (fig. 150). If the veins at the base are longest, the leaf is *ovate* or egg-shaped, as in Chick-weed (fig. 152), and if those at the apex are longest, the leaf is *obovate*, or inversely egg-shaped. Leaves are *cuneate* (*cuneus*, a wedge) or wedge-shaped, in Saxifraga (fig. 155); *spathulate*, or spatula-like, having a broad rounded apex, and tapering down to the stalk in the Daisy (fig. 148); *subulate* (fig. 167), or narrow and tapering like an awl (*subula*); *acuminate*, or drawn out into a long point, as in Ficus religiosa (fig. 159), *mucronate*, with a hard stiff point or mucro at the apex (figs. 160 and 143). When the parenchyma is deficient at the *apex* so as to form two rounded lobes, the leaf is *obcordate* or inversely heart-shaped; when the deficiency is very slight, the leaf is called *emarginate* (fig. 143) as having a portion taken out of the margin; when the apex is merely flattened or slightly depressed



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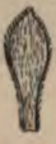

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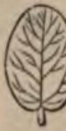

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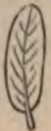

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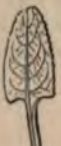

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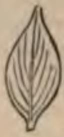

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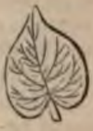

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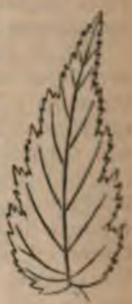

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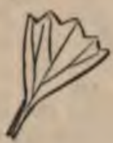

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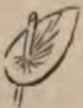

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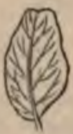

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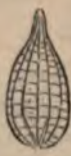

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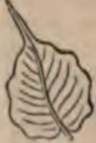

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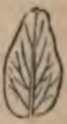

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Fig. 147.—Linear, or acicular leaf of Fir. Fig. 148.—Spathulate leaf of Daisy

Fig. 149.—Oval leaf. Fig. 150.—Oblong leaf.

Fig. 151.—Petiolated, reticulated, somewhat oblong leaf, truncate at the base.

Fig. 152.—Ovate pointed leaf. Fig. 153.—Cordate pointed leaf.

Fig. 154.—Ovato-lanceolate leaf, *i. e.* lanceolate in its general contour, but ovate at the base doubly serrated, or having large and small serratures alternately at the margin.

Fig. 155.—Cuneate or wedge-shaped leaf of Saxifraga, ending in an abrupt or truncate manner, and toothed or dentate at the apex.

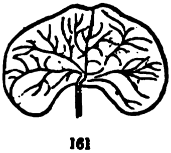
Fig. 156.—Perfoliate leaf of Bupleurum, formed by lobes uniting at the base on the opposite side of the stem from that to which the leaf is attached.

Fig. 157.—Retuse leaf, *i. e.* slightly depressed at the apex. Margin slightly waved.

Fig. 158.—Ovate, five-ribbed leaf.

Fig. 159.—Rounded acuminated leaf of Ficus religiosa, with the margin crenate or slightly sinuous. Fig. 160.—Sub-ovate, retuse, mucronate leaf.

(fig. 157), the leaf is *retuse* (*retusus*, blunt); and when the apex ends abruptly in a straight margin, as in the Tulip tree (fig. 163), the leaf is *truncate*. When the venation is prolonged downwards at an obtuse angle with the midrib, and rounded lobes are formed, as in Dog-violet, the leaf is *cordate* or heart-shaped (fig. 153), or kidney-shaped (*reniform*) when the apex is rounded (fig. 161), as in Asarum. When the lobes are prolonged downwards and acute (fig. 165), the leaf is *sagittate* (*sagitta*, an arrow); when they proceed at right angles, as in Rumex Acetosella, the leaf is *hastate* (*hasta*, a halbert) or halbert-shaped. When a simple leaf is divided at the base into two leaf-like appendages (fig. 169), it is called *auriculate* (*auricula*, the ear). When the veins spread out in various planes, and there is a large development of cellular tissue, so as to produce a succulent leaf, such forms occur as *conical*, *prismatical*, *ensiform* or sword-like (*ensis*, a sword), *acinaciform* (*acinaces*, a scimitar), or scimitar-shaped (fig. 172), and *dolabriform* (*dolabra*, an axe) or axe-shaped (fig. 171). When the development of cells is such that they more than fill up the spaces between the veins, the margins become *wavy*, *crisp*, or *undulated*, as in Rumex crispus and Rheum undulatum (fig. 174). By cultivation the cellular tissue is often much increased, giving rise to the *curled* leaves of Greens, Savoys, Cresses, Lettuce, &c.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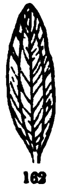
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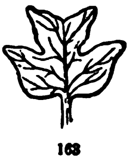
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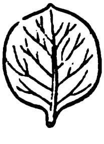
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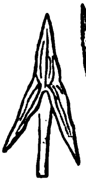
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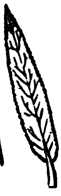
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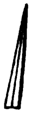
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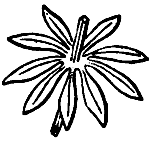
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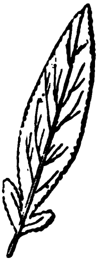
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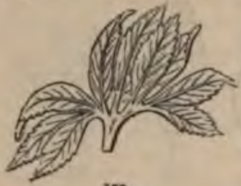
151. **Compound Leaves** are those in which the divisions extend to

Fig. 161.—Reniform or kidney-shaped entire leaf of Asarum. Radiating venation.
Fig. 162.—Elliptical and somewhat lanceolate leaf; three-ribbed.
Fig. 163.—Three-lobed, truncate, or abrupt leaf of Liriodendron tulipifera.
Fig. 164.—Rounded entire leaf, ending in a short point.
Fig. 165.—Sagittate or arrow-shaped leaf of Sagittaria.
Fig. 166.—Lanceolate, acute leaf, with minute teeth or dentations at the margin.
Fig. 167.—Subulate or awl-shaped leaf.
Fig. 168.—Whorl or verticil of linear-obovate leaves.
Fig. 169.—Auriculate lanceolate leaf, oblique at the base, with minute toothings at the margin.

the midrib, or petiole (fig. 175), and receive the name of *foliola* or *leaflets*. The midrib, or petiole, has thus the appearance of a branch with separate leaves attached to it, but it is considered properly as one leaf, because in its earliest state it arises from the axis as a single piece, and its subsequent divisions in the form of leaflets are all in one plane. When a compound leaf dies, it usually separates as one piece. The leaflets are either sessile (fig. 176), or have stalks, called *petiolules* (fig. 175), according as the vascular bundles of the veins spread out or divaricate at once, or remain united for a certain length.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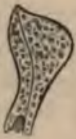
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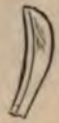
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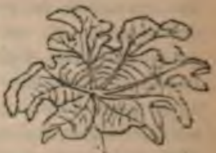
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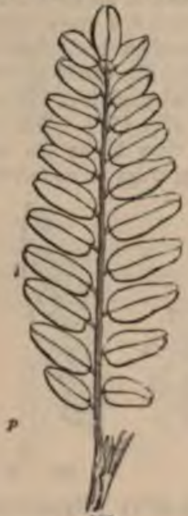

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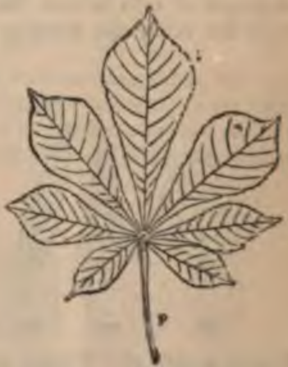

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Fig. 170.—Pedate or pedatifid leaf of Hellebore. Radiating venation.

Fig. 171.—Dolabriform or axe-shaped fleshy succulent leaf. Hidden veined.

Fig. 172.—Acinaciform or scimitar-shaped succulent leaf. Hidden-veined.

Fig. 173.—Oval leaf with converging veins; not reticulated.

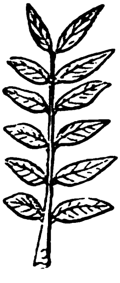
Fig. 174.—Palmately-lobed leaf, crisp or undulated at the margin. Radiating venation.

Fig. 175.—Leaf of Robinia pseudo-acacia, often called Acacia. The leaf is impari-pinnate, or alternately pinnate. The pinnæ are supported on stalks or petiolules. *p*, Petiole or leaf-stalk. *l*, Lamina or blade divided into separate leaflets or pinnæ.

Fig. 176.—Septenate leaf of Æsculus Hippocastanum or Horse Chestnut. *p*, Petiole. *l*, Lamina, divided into seven separate leaflets.

152. Compound leaves have been classified according to the nature of the venation, and the development of parenchyma. In a feather-veined leaf, if the divisions extend to the midrib, and each of the primary veins spreads out or branches so as to become covered with parenchyma, and thus form separate leaflets, which are usually articulated to the petiole or midrib (fig. 177), the leaf is *pinnate* (*pinna*, a wing or feather). If the midrib and primary veins are not covered with parenchyma, while the *secondary* (or those coming off in a feather-like manner from the primary veins) are, and separate leaflets are thus formed which are usually articulated with the veins, the leaf is *bipinnate* (fig. 178). In this case the secondary veins form as it were partial petioles. A farther sub-division, in which the *tertiary* veins only are covered with parenchyma and have separate leaflets, gives *tripinnate* or *decompound*, in which case the tertiary veins form the partial petioles; and a leaf divided still more is called *supradecompound* (fig. 179).

153. When a pinnate leaf has one pair of leaflets, it is *unijugate* (*unum*, one, and *jugum*, a yoke); when it has two pairs, it is *bijugate*; many pairs, *multijugate* (fig. 175). When a pinnate leaf ends in a pair of pinnæ (fig. 177,) it is *equally* or *abruptly pinnate* (pari-pinnate); when there is a single terminal leaflet (fig. 175), the leaf is *unequally pinnate* (impari-pinnate); when the leaflets or pinnæ are placed alternately on either side of the midrib, and not directly opposite to each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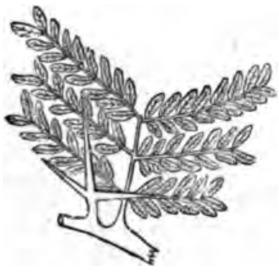
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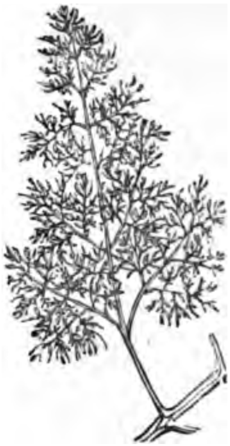
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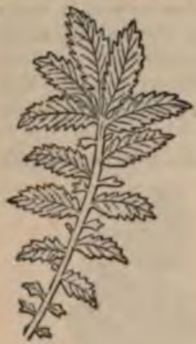
Fig. 177.—Pari-pinnate leaf with six pairs of pinnæ (*sexjugate*).
Fig. 178.—Bipinnate leaf, with sessile foliola or leaflets.
Fig. 179.—Part of the supradecompound leaf of Laserpitium hirsutum.

other, the leaf is *alternately pinnate* (fig. 175); and when the pinnæ are of different sizes, the leaf is *interruptedly pinnate* (fig. 180).

154. In the case of a leaf with radiating venation, if the ribs are separately covered with parenchyma, and each leaflet is articulated to the petiole, the leaf becomes *ternate* (figs. 141, 181) if there are three divisions; *quaternate*, if four (fig. 142); *quinate*, if five; *septenate*, if seven (fig. 176), and so on.[*] If the three ribs of a ternate leaf subdivide each into three primary veins, which become covered with parenchyma so as to be separate articulated leaflets, the leaf is *biternate*; and if another three-fold division takes place, it is *triternate* (fig. 182).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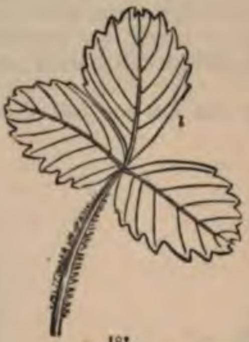

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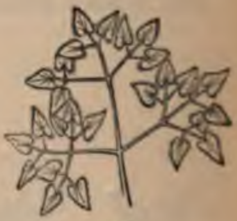
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155. **Petiole or Leaf-stalk.**—This is the part which unites the limb or blade of the leaf to the stem (figs. 132, and 175 *p*). It is absent in *sessile* leaves, and in many sheathing leaves is not well defined. It consists of one or more bundles of vascular tissue, with a varying amount of parenchyma. The vessels are, spiral-vessels connected with the medullary sheath in Exogens and with the fibro-vascular bundles in Endogens, porous vessels and other forms of fibro-vascular tissue, woody tissue, and laticiferous vessels. These vessels are enclosed in an epidermal covering, with few stomata, and are more or less compressed. When the vascular bundles reach the base of the lamina, they separate and spread out in various ways, as already described under venation. A large vascular bundle is continued through the lamina to form the midrib (fig. 133, *n m*), and sometimes several large bundles form separate ribs (figs. 146, 162), whilst the ramifications of the smaller bundles constitute the veins.

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[*] Some apply the term *digitate* to radiating compound leaves with five or seven leaflets.

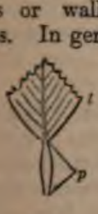
Fig. 180.—Impari and alternately pinnate leaf. Leaflets or pinnæ sessile, and serrated at the margin.

Fig. 181.—Ternate leaf of Strawberry. Margin of leaflets, toothed or dentate. *p*, Petiole with projecting hairs. *l*, Lamina divided into three leaflets.

Fig. 182.—Triternate leaf. Leaflets cordate.

156. At the place where the petiole joins the stem, there is frequently an articulation or a constriction with a tendency to disunion, and at the same time there exists a swelling (fig. 203 p), called *pulvinus* (*pulvinus*, a cushion), formed by a mass of cellular tissue, the cells of which occasionally exhibit the phenomenon of contractility. At other times the petiole is not articulated, but is either continuous with the stem, or forms a sheath around it. At the point where the petiole is united to the lamina, or where the midrib joins the leaflets of a compound leaf, there is occasionally a cellular dilatation called *struma* (*struma*, a swelling), with an articulation. This articulation or joint is by many considered as indicating a compound leaf, and hence the leaf of the orange is considered as such, although it consists of one undivided lamina (fig. 185). In articulated leaves, the pulvinus may be attached either to the petiole or to the axis, and may fall with the leaf, or remain attached to the stem. When articulated leaves drop, their place is marked by a cicatrix or scar, seen below the bud in fig. 203. In this scar, the remains of the vascular bundles, c, are seen; and its form furnishes characters by which particular kinds of trees may be known when not in leaf. In the case of many Palms and Tree-ferns, the scars or cicatrices of the leaves are very conspicuous. In fossil plants important characters are founded on them.

157. The petiole varies in length, being usually shorter than the lamina, but sometimes much longer. In some palms it is fifteen or twenty feet long, and is so firm as to be used for poles or walking-sticks. In general, the petiole is more or less rounded in its form, the upper surface



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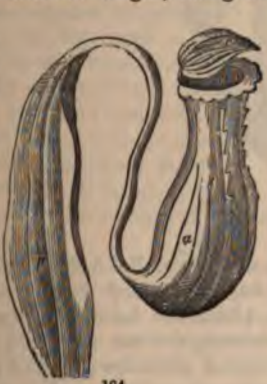

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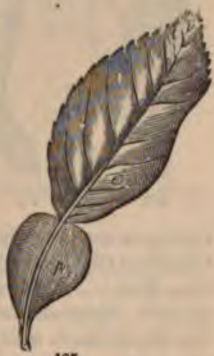

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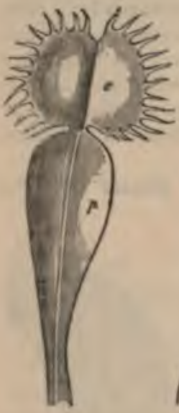
Fig. 183.—Leaf with a quadrangular toothed lamina or blade, l, and an inflated petiole, p, containing air cells.

Fig. 184.—Ascidium or pitcher of Nepenthes. p, Winged petiole which becomes narrowed, and then expands so as to form the pitcher by being folded on itself. e, The operculum or lid, formed by the blade of the leaf, and articulated to the pitcher.

Fig. 185.—Leaf of Orange, which some call compound. p, Dilated or winged petiole, united by an articulation to the blade. In such a leaf, if the vessels of the petiole were developed in a circular manner, so as to form a pitcher, the lamina or blade would form the jointed lid.

being flattened or grooved. Sometimes it is compressed laterally, as in the Aspen, and to this peculiarity the trembling of the leaves of this tree is attributed. In aquatic plants, the leaf-stalk is sometimes distended with air (fig. 183 *p*), as in Pontederia and Trapa, so as to float the leaf. At other times it is winged, or has a leaf-like appearance, as in the pitcher plant (fig. 184 *p*), orange (fig. 185 *p*), lemon, and Dionæa (fig. 186 *p*). In some Australian Acacias, and in some species of Oxalis, Bupleurum, &c., the petiole is flattened in a vertical direction, the vascular bundles separating immediately after quitting the stem, and running nearly parallel from base to apex. This kind of petiole (fig. 188 *p*), has been called *Phyllodium* (φύλλον, a leaf, and εἶδος, form). In these plants the laminæ or blades of the leaves are pinnate, bipinnate, or ternate, and are produced at the extremities of the phyllodia in a horizontal direction (fig. 188 *l*); but in many instances they are not developed, and the phyllodium serves the purpose



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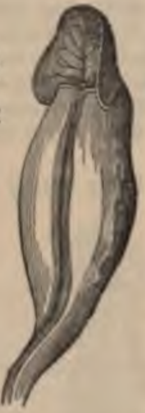

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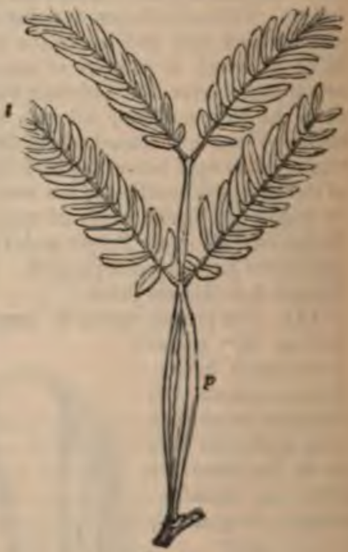

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Fig. 186.—Leaf of Dionæa muscipula, or Venus' Fly-trap. *p*, Dilated or winged petiole. *e*, Jointed blade, the two fringed halves of which fold on each other, when certain hairs on the upper surface are touched.

Fig. 187.—Ascidium, or Pitcher of Sarracenia, formed by the petiole of the leaf. The lid is not articulated to the pitcher as in Nepenthes (fig. 184).

Fig. 188.—Leaf of Acacia heterophylla. *p*, Phyllodium or enlarged petiole, with straight venation. *l l*, Lamina or blade which is bipinnate. The blade is frequently awanting, and the phyllodium is the only part produced.

of a leaf. Hence, some Acacias are called leafless. These phyllodia, by their vertical position, and their peculiar form, give a remarkable aspect to vegetation. On the same Acacia, there occur leaves with the petiole and lamina perfect; others having the petiole slightly expanded or winged, and the lamina imperfectly developed; and others in which there is no lamina, and the petiole becomes large and broad. Some petioles, in place of ending in a lamina, form a *tendril* or *cirrhus* (¶ 201), so as to enable the plant to climb.

Stipules.

158. At the place where the petiole joins the axis, a sheath (*vagina*) is sometimes produced, which embraces the whole or part of the circumference of the stem (fig. 132 *g*). This sheath is formed by the divergence of the vascular bundles which separate so as to form a hollow cavity towards the stem. The sheath is occasionally developed to such a degree as to give a character to the plants. Thus, in the Rhubarb tribe, it is large and membranous, and has received the name of *ochrea* or boot (fig. 132 *g*); while in Palms it forms a kind of network, to which the name of *reticulum* has been given (¶ 57); and in umbelliferous plants, it constitutes the *pericladium* (περὶ, around, and κλάδος, a branch). In place of a sheath, leaves are occasionally produced at the base of the petiole (fig. 189 *s s*), which have been denominated *stipules* (*stipula*, straw or husk). These stipules are often two in number, and they are important as supplying characters in certain natural orders. Thus they occur in the Pea and Bean family, in Rosaceous plants, and the Cinchona bark family. They are rarely met with in Endogens, or in Exogens with sheathing petioles, and they are not common in Exogens with opposite leaves. Plants having stipules, are *stipulate*; those having none, are *exstipulate*.

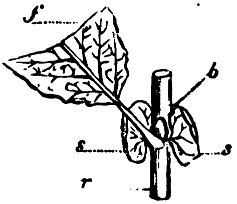

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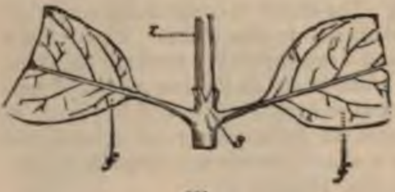
Fig. 189.—Portion of a branch, *r*, of Salix aurita, bearing a single petiolate leaf, *f*, which has been cut across. *s s*, Stipules. *b*, Bud in the axil of the leaf.

159. Stipules are formed by some of the vascular bundles diverging as they leave the stem, and becoming covered with parenchyma so as to resemble true leaves. Like leaves they are large or small, entire or divided, deciduous or persistent, articulated or nonarticulated. Their lateral position at the base of the petiole, distinguishes them from true leaves. In the Pansy, the true leaves are stalked and crenate, while the stipules are large, sessile, and pinnatifid. In Lathyrus Aphaca, and some other plants, the true pinnate leaves are abortive, the petiole forms a tendril, and the stipules alone are developed, performing the office of leaves.

160. When stipules are attached separately to the stem at the base of the leaf, they are called *caulinary*. Thus, in fig. 189, *r* is a branch of Salix aurita, with a leaf, *f*, having a bud, *b*, in its axil, and two caulinary stipules, *s s*. When stipulate leaves are opposite to each other at the same height on the stem, it occasionally happens that the stipules at either side unite wholly or partially, so as to form an *interpetiolary* or *interfoliar* (*inter*, between) stipule, as in Cinchona (fig. 190 *s*). In the case of alternate leaves, the stipules at the base of each leaf are sometimes united to the petiole and to each other, so as to form an *adnate*, *adherent*, or *petiolary* stipule, as in the Rose (fig. 191 *s*), or an *axillary* stipule, as in Houttuynia cordata (fig. 192 *s*).



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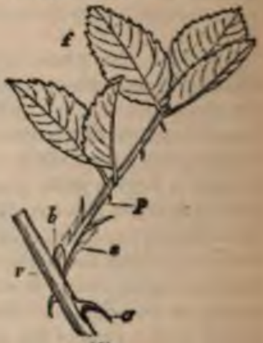

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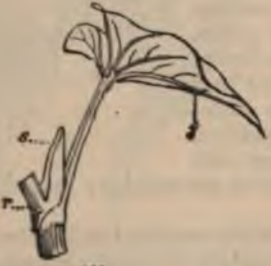

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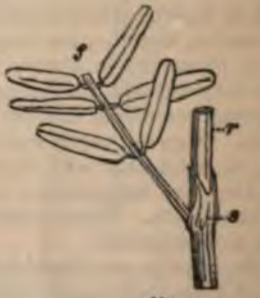

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Fig. 190.—Branch, *r*, and two leaves, *f f*, of Cephalanthus occidentalis. *s*, Interpetiolary or interfoliar stipule, formed by the partial union of two.

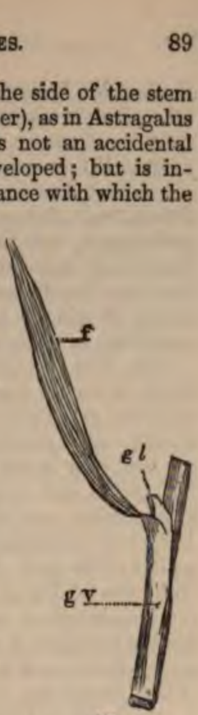
Fig. 191.—Portion of a branch, *r*, of Rosa canina, or dog-rose, bearing a single leaf, *f*, with its petiole, *p*, its petiolary or adnate stipules, *s*, its axillary bud, *b*, and its aculei or prickles, *a*.

Fig. 192.—Portion of a branch, *r*, of Houttuynia cordata, with a leaf, *f*, and an axillary stipule, *s*, formed by the union of two.

Fig. 193.—Branch, *r*, and portion of the leaf, *f*, of Astragalus Onobrychis, with a synochreate stipule, *s*, formed by the union of two stipules on the opposite side of the branch from that to which the leaf is attached. The leaf is pinnate, and in the figure three pairs of leaflets or pinnæ are left.

In other instances, the stipules unite together on the side of the stem opposite the leaf, and become *synochreate* (συν, together), as in Astragalus (fig. 193 *s*). The union or adhesion of stipules is not an accidental occurrence taking place after they have been developed; but is intimately connected with the general law, in accordance with which the parts of the plants are formed.

161. Stipules are sometimes large, enveloping the leaves in the young state, and falling off in the progress of growth, as in Ficus, Magnolia, and Potamogeton; at other times they are so minute as to be scarcely distinguishable without the aid of a lens, and so fugaceous as to be visible only in the very young state of the leaf. In grasses, the sheath or sheathing petiole (fig. 194 *g v*) has a prolongation or folding of the epidermis * at its upper part, distinct from the leaf, to which the name of *ligule* (*ligula*, a small slip) has been given (fig. 194 *g l*). Some consider it as equivalent to a stipule. It is either long or short, acute or blunt, entire or divided, and thus gives rise to various characters. At the base of the leaflets or foliola of a compound leaf, small stipules are occasionally produced, to which some have given the name of *stipels*.



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Anomalous Forms of Leaves and Petioles.

162. Variations in the structure and forms of leaves and leaf-stalks are produced by the increased development of cellular tissue, by the abortion or degeneration of parts, by the multiplication or repetition of parts, and by adhesion. When cellular tissue is developed to a great extent, leaves become succulent, and occasionally assume a crisp or curled appearance. Such changes take place naturally, but they are often increased by the art of the gardener; and the object of many horticultural operations is to increase the bulk and succulence of leaves. It is in this way that Cabbages and Greens are rendered more delicate and nutritious.

163. In some plants true leaves are not produced, their place being occupied by dilated petioles or phyllodia (¶ 157), or by stipules (¶ 159). In other instances scales are formed instead of leaves, as in

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* See *Deduplication*, under the head of *Corolla*, page 193.

Fig. 194.—Portion of a leaf of Phalaris arundinacea, one of the grasses. *f*, Laminar merithal or blade of the leaf, with straight parallel venation. *g v*, Vaginal, or sheathing portion representing the petiole, ending in a membranous process or ligule, *g l*.

Orobanche, Lathræa, and young Asparagus (fig. 110 *l*). Divisions take place in leaves when there is a multiplication of their parts; and a union of two or more leaves, or of parts of leaves, occurs in many cases. When two lobes at the base of a leaf are prolonged beyond the stem and unite (fig. 156), the leaf is *perfoliate* (*per*, through, and *folium*, leaf), the stem appearing to pass through it, as in Bupleurum perfoliatum, and Chlora perfoliata; when two leaves unite by their bases they become *connate* (*con*, together, and *natus*, born), as in Lonicera Caprifolium; and when leaves adhere to the stem, forming a sort of winged or leafy appendage, they are *decurrent* (*decurro*, to run down or along), as in Thistles.

164. The vascular bundles and cellular tissue are sometimes developed in such a way as to form a circle, with a hollow in the centre, and thus give rise to what are called *fistular* (*fistula*, a pipe) or hollow leaves, and to *ascidia* (ἀσκίδιον, a small bag) or *pitchers*. Hollow leaves are well seen in the Onion. Pitchers are formed either by petioles or by laminæ, and they are composed of one or more leaves. In some Convallarias, two leaves unite to form a cavity. In Sarracenia (fig. 187) and Heliamphora, the pitcher is composed apparently of the petiole of the leaf. In Nepenthes (fig. 184) and perhaps in Cephalotus, while the folding of a winged petiole, *p*, forms the pitcher, *a*, the lid, *e*, which is united by an articulation, corresponds to the lamina. This kind of ascidium is called *calyptrimorphous* (καλύπτρα, a covering, and μορφή, form), and may be considered as formed by a leaf such as that of the Orange (fig. 185); the lamina, *e*, being articulated to the petiole, *p*, which, when folded, forms the pitcher. In Dischidia Rafflesiana, a climbing plant of India, the pitchers, according to Griffith, are formed by the lamina of the leaf, and have an open orifice into which the rootlets at the upper part of the plant enter. These pitchers would seem therefore to contain a supply of fluid for the nourishment of the upper branches of the plant. In Utricularia, the leaves form sacs called *ampullæ*. Some suppose that pitchers are not due to folding and adhesion, but that they are produced by a hollowing out of the extremity of the stalk.

Structure and Form of Leaves in the Great Divisions of the Vegetable Kingdom.

165. **Exogenous or Dicotyledonous Leaves.**—In Exogens, the venation is reticulated, the veins coming off at various angles and forming an angular net-work of vessels (fig. 136), and the tracheæ communicating with the medullary sheath. They are frequently articulated, exhibit divisions at their margin, and become truly compound. There are no doubt instances in which the veins proceed in a parallel manner, but this will be found to occur chiefly in cases where the petiole may be considered as occupying the place of the leaf. Examples of

this kind are seen in Acacias (fig. 188), as well as in Ranunculus gramineus, and Lingua.

166. **Endogenous or Monocotyledonous Leaves.**—In Endogens, the leaves do not present an angular net-work of vessels, nor do they exhibit divisions on their margin. Their venation is generally parallel, and their margin entire (figs. 135, 194). Exceptions to this rule occur in some plants, as Tamus and Dioscorea, which have been called Dictyogens by Lindley, on account of their somewhat netted venation; and in Palms, in which although the leaves are entire at first, they afterwards become split into various lobes. Endogenous leaves are rarely stipulate, unless the ligule of grasses be considered as being a stipule. Their leaves are often sheathing, continuous with the stem (forming a spurious stem in Bananas), and do not fall off by an articulation. When there is only a slight divergence of their veins, they may be looked upon more as enlarged and flattened petioles than as true laminæ. This remark is illustrated by the leaves of Typha and Iris. In some Endogens, as in Sagittaria sagittifolia, the submerged and floating leaves are narrow, like petioles, while those growing erect above the water expand and assume an arrow-like shape (fig. 165).

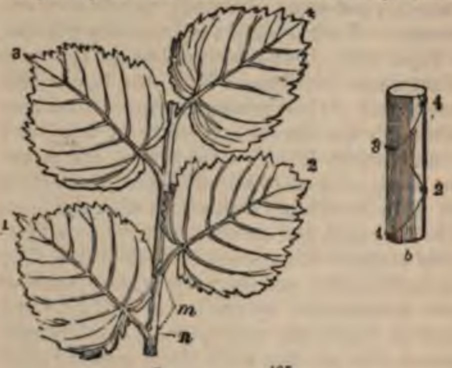
167. **Acrogenous or Acotyledonous Leaves.**—In Acrogens, the leaves vary much; being entire or divided, petiolated or sessile, often feather-veined, occasionally with radiating venation, the extremities of the veins being forked. The fibro-vascular bundles of the leaves resemble those of the stem both in structure and arrangement. In Thallogens, the leaves when present have no vascular venation. In many of them, as Lichens, Fungi, and Algæ, there are no true leaves.

Phyllotaxis, or the Arrangement of the Leaves on the Axis.

168. Leaves occupy various positions on the stem and branches, and have received different names according to their situation. Thus, leaves arising from the crown of the root, as in the Primrose, are called *radical;* those on the stem are *cauline;* on the branches, *ramal;* on flower-stalks, *floral leaves.* The first leaves developed are denominated *seminal* (*semen*, a seed), or *cotyledons* (κοτυληδὼν, a name given to a plant); and those which succeed are *primordial* (*primus*, first, and *ordo*, rank).

169. The arrangement of the leaves on the axis and its appendages is called *phyllotaxis* (φύλλον, a leaf, and τάξις, order). In their arrangement leaves follow a definite order. It has been stated already (¶ 67) that there are regular *nodes* or points on the stem (fig. 195 *n*) at which leaves appear, and that the part of the stem between the nodes is the *internode* or *merithal* (fig. 195 *m*). Each node is capable of giving origin to a leaf. Occasionally several nodes are approximated so as to form as it were one, and then several leaves may be produced at the same height on the stem. When two leaves are thus produced,

one on each side of the stem or axis, and at the same level, they are called *opposite* (fig. 196); when more than two are produced (figs. 168, 197), they are *verticillate* (*verto*, I turn), and the circle of leaves is then called a *verticil* or *whorl*. When leaves are opposite, the pairs which are next each other, but separated by an internode, often cross at right angles (fig. 196 *a b*), or *decussate* (*decusso*, I cut crosswise), following thus a law of alternation. The same occurs in verticils, the leaves of each whorl being alternate with those of the whorl next to it; or, in other words, each leaf in a whorl occupying the space between two leaves of the whorl next to it. There are considerable irregularities, however, in this respect, and the number of leaves in different whorls is not always uniform, as may be seen in Lysimachia vulgaris.



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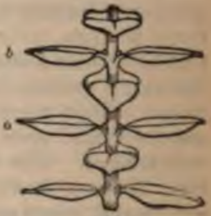

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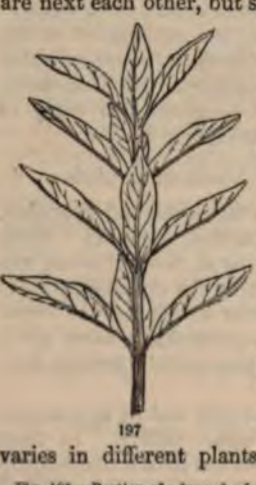

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170. When a single leaf is produced at a node, and the nodes are separated so that each leaf occurs at a different height on the stem, the leaves are *alternate* (fig. 198). The relative position of alternate leaves varies in different plants, although it is tolerably uniform in each

Fig. 195.—Portion of a branch of a Lime tree, with four leaves arranged in a distichous manner, or in two rows. *a*, The branch with the leaves numbered in their order, *n* being the node, and *m* the internode or merithal. *b*, Is a magnified representation of the branch, showing the cicatrices of the leaves and their spiral arrangement, which is expressed by $\frac{1}{2}$, or one turn of the spiral and two leaves.

Fig. 196.—Opposite, decussate leaves of Pimelea decussata. *a*, A pair of opposite leaves. *b*, Another pair placed at right angles.

Fig. 197.—Leaves of Lysimachia vulgaris, in verticils or whorls of three. The leaves of each verticil alternate with those of the verticils next it. In this plant the number of the leaves in a verticil often varies.

species. In fig. 195, leaf 1 arises from a node, *n;* leaf 2 is separated by an internode or merithal, *m,* and is placed to the right or left; while leaf 3 is situated directly above leaf 1. The arrangement in this case is *distichous* (δὶς, twice, and στίχος, order), or the leaves are arranged in two rows. In fig. 199, on the other hand, the fourth leaf is that directly above the first, and the arrangement is *tristichous* (τρεῖς, three, and στίχος, order). The same arrangement continues throughout the stems, so that in fig. 199 the 7th leaf is above the 4th, the 10th above the 7th; also the 5th above the 2nd, the 6th above the 3rd, and so on. There is thus throughout a tendency to a spiral arrangement, the number of leaves in the spire or spiral cycle, and the number of turns varying in different plants. In plants whose leaves are close to each other, the spiral tendency is easily seen. In the Screw pine (Pandanus odoratissimus), in the Pine-apple family, and in some Palms, as Copernicia cerifera, the screw-like arrangement of the leaves is obvious. This mode of development prevails in all parts of plants, and may be considered as depending on their manner of growth in an upward and at the same time in a lateral direction. Alternation is looked upon as the normal arrangement of all parts of plants. This arrangement is liable to be interrupted by many causes, so that its distinct existence cannot be always detected.

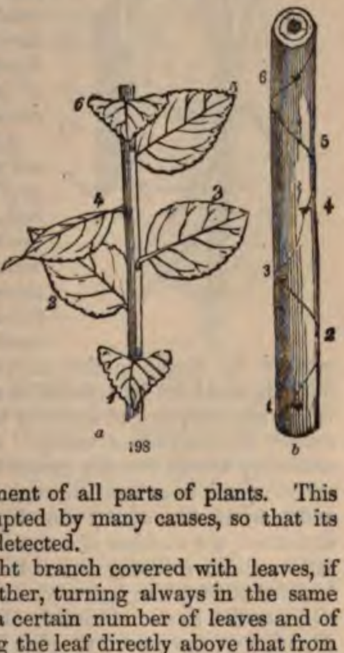

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Fig. 198.—Part of a branch of a Cherry with six leaves, the 6th being placed vertically over the first, after two turns of the spiral. This is expressed by $\frac{2}{5}$ or the quincunx. *a*, The branch, with the leaves numbered in order *b*, A magnified representation of the branch, showing the cicatrices of the leaves or their points of insertion, and their spiral arrangement.

171. In a regularly-formed straight branch covered with leaves, if a thread is passed from one to the other, turning always in the same direction, a spiral is described, and a certain number of leaves and of complete turns occur before reaching the leaf directly above that from which the enumeration commenced. This arrangement has been reduced to mathematical precision,* and Braun has expressed it by a fraction, the numerator of which indicates the number of turns, and the denominator the number of leaves in the spiral cycle. Thus, in fig. 198 *a b*, the cycle consists of five leaves, the 6th leaf

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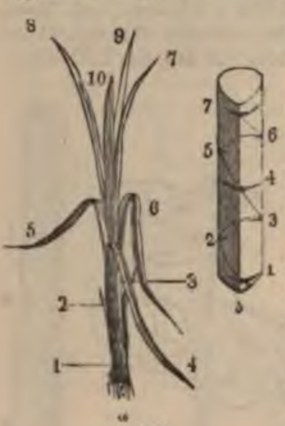
* For a full account of Phyllotaxis, see Bravais Mem. sur la Disposition Géometrique des Feuilles. Annales des Sciences Naturelles. Jan. and Feb. 1837.

being placed vertically over the first, the 7th over the 2nd, and so on; while the number of turns between the 1st and 6th leaf is two: hence, this arrangement is indicated by the fraction $\frac{2}{5}$. In other words, the distance or divergence between the first and second leaf, expressed in parts of a circle, is $\frac{2}{5}$ of a circle, or $360 \div \frac{2}{5} = 144°$. In fig. 195, *a b*, the spiral is $\frac{1}{2}$, *i.e* one turn and two leaves; the third leaf being placed vertically over the first, and the divergence between the first and second leaf being one-half the circumference of a circle, $360 \div \frac{1}{2}, = 180°$. Again, in fig. 199, *a b*, the number is $\frac{1}{3}$, or one turn and three leaves, the angular divergence being 120°.



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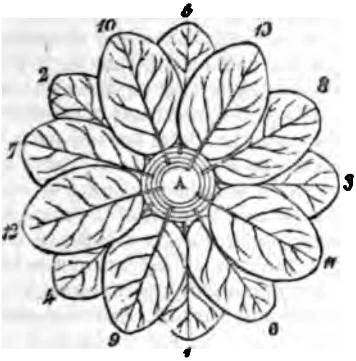
172. In cases where the internodes are very short, and the leaves are closely applied to each other, as in the Houseleek, it is difficult to trace what has been called the *generating spiral*, or that which passes through every leaf of the cluster. Thus in fig. 200, there are thirteen leaves which are numbered in their order, and five turns of the spiral marked by circles in the centre ($\frac{5}{13}$ indicating the arrangement); but this could not be detected at once. So also in Fir cones (fig. 201), which are composed of scales or modified leaves, the generating spiral cannot be determined easily. In such cases, however, there are secondary spirals running parallel to each other, as is seen in fig. 201, where spiral lines pass through scales numbered 1, 6, 11, 16, &c., and 1, 9, 17, &c., and by counting those which run parallel in different directions, the number of scales intervening between every two in the same parallel coil may be ascertained. Thus, in fig. 201, it will be found that there are five secondary spirals running towards the right and parallel to each other, the first passing through the scales 1, 6, 11, 16, &c.; the second through 9, 14, 19, 24, &c.; the third through 17, 22, 27, 32, 37, &c.; the fourth through 30, 35, 40, 45, &c.; the fifth through 43, 48, 53, &c. The number of these secondary spirals indicates the number of scales intervening between every two scales in each of these spirals—the common difference being five. Again, it will be found on examination that there is a number of secondary spirals running to the left, in which the common difference between every two scales is eight, and that this corresponds to the number of

Fig. 199.—Young plant of Cyperus esculentus, with leaves in three rows, or tristichous, expressed by the fraction $\frac{1}{3}$, or one turn and three leaves. *a*, The plant, with its leaves numbered in their order. *b*, Magnified representation of the stem, showing the insertion of the leaves and their spiral arrangement.

secondary spirals, the first of which passes through the scales 1, 9, 17, &c.; the second through 6, 14, 22, 30, &c.; the third through 3, 11, 19, 27, 35, 43, and so on. Thus it is that, by counting the secondary spirals, all the scales may be numbered, and, by this means, the generating spiral may be discovered.



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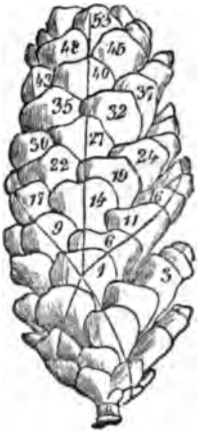

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173. The primitive or generating spiral may pass either from right to left or from left to right. It sometimes follows a different direction in the branches from that pursued in the stem. When it follows the same course in the stem and branches, they are *homodromous* (ὅμοιος, similar, and δρόμος, a course); when the direction differs, they are *heterodromous* (ἕτερος, another.) In different species of the same genus the phyllotaxis frequently varies.

174. Considering alternation as the usual leaf-arrangement, some have supposed that opposite leaves are owing to the development of two spirals in opposite directions, while others look upon them as produced by two nodes coming close together without an internode. A verticil, in the latter view, will be the result of the non-development of more than one internode, and may occur in plants, the normal arrangement of whose leaves is alternate. Thus, in fig. 195, if the space between 1 and 2 were obliterated, or the internode, *m*, not developed,

Fig. 200.—Cycle of thirteen leaves placed closely together so as to form a rosette, as in Sempervivum. A, is the very short axis to which the leaves are attached. The leaves are numbered in their order, from below upwards. The circles in the centre indicate the five turns of the spiral, and show the insertion of each of the leaves. The divergence is expressed by the fraction 5-thirteenths.

Fig. 201.—Cone of Pinus alba, with the scales or modified leaves numbered in the order of their arrangement on the axis of the cone. The lines indicate a rectilinear series of scales, and two lateral secondary spirals, one turning from left to right, the other from right to left.

the leaves would be opposite. In fig. 198, if the spaces between each of the leaves were obliterated, there would be a verticil of five leaves. In many plants there is a law of arrestment of development, by which opposite and verticillate leaves are naturally produced: but in such cases the alternation is still seen in the arrangement of the different *clusters* of leaves.

175. In some cases, the effect of interruption of growth, in causing alternate leaves to become opposite and verticillate, can be distinctly shown, as for instance in Rhododendron ponticum. In other cases, parts which are usually opposite or verticillate, become alternate by the vigorous development of the axis: and on different parts of the same stem, as in Lysimachia vulgaris, there may be seen alternate, opposite, and verticillate leaves. When the interruption to development takes place at the end of a branch, the leaves become *fasciculate* (*fasciculus*, a bundle) or clustered, as in the Larch. A remarkable instance of the shortening of internodes, and the clustering of leaves, occurred in the Palm house of the Botanic Garden of Edinburgh, in the case of a Bamboo which was exposed for many months to a low temperature, during the time that the roof of the house was being renewed. The plant had been growing rapidly, with its internodes of the usual length, but it was suddenly arrested near the summit, the internodes became gradually shortened, till the nodes were close to each other, and the leaves came off in bunches. All modifications of leaves follow the same laws of arrangement as true leaves—a fact which is of importance in a morphological point of view.

176. In Exogenous plants, the first leaves produced, or the cotyledons, are opposite. This arrangement often continues during the life of the plant, but at other times it changes. Some tribes of plants are distinguished by their opposite or verticillate, others by their alternate, leaves. Labiate plants have decussate leaves, while Boraginaceæ have alternate leaves, and Tiliaceæ have distichous leaves in general; Cinchonaceæ have opposite leaves; Galiaceæ, verticillate. Such arrangements as $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, and $\frac{8}{21}$, are common in Exogens. The first of these, called *quincunx* (*quincunx*, an arrangement of five), is met with in the Apple, Pear, and Cherry (fig. 198); the second, in the Bay, Holly, Plantago media; the third, in the cones of Pinus alba (fig. 201); and the fourth, in those of the Pinus Picea. In Endogenous plants, there is only one seed-leaf or cotyledon produced, and hence the arrangement is at first alternate; and it generally continues so more or less. Such arrangements as $\frac{1}{2}$ $\frac{1}{3}$ (fig. 199), and $\frac{2}{5}$, are common in Endogens, as in Grasses, Sedges, and Lilies. In Acrogens, the leaves assume all kinds of arrangement, being opposite, alternate, and verticillate. It has been found in general that, while the number 5 occurs in the phyllotaxis of Exogens, 3 is common in that of Endogens.

177. Although there is thus, in the great divisions of the vegetable kingdom, a tendency to certain definite numerical arrangements, yet there are many exceptions. In speaking of Palms, which are endogenous plants, Martius states that the leaves of different species exhibit the following spirals—$\frac{1}{2}$, $\frac{3}{5}$, $\frac{5}{7}$, $\frac{5}{8}$, $\frac{7}{9}$, $\frac{8}{13}$, $\frac{13}{21}$. $\frac{21}{24}$. In the species of the genus Pinus, $\frac{2}{5}$, $\frac{5}{13}$, $\frac{13}{34}$, $\frac{8}{21}$, $\frac{21}{55}$, occur. Thus, while it has been shown that the phylloplastic (φύλλον, a leaf, and πλαστικός, formative), or leaf-formative power, moves in a spiral round the axis, it has been found impossible to apply phyllotaxis satisfactorily to the purposes of classification.

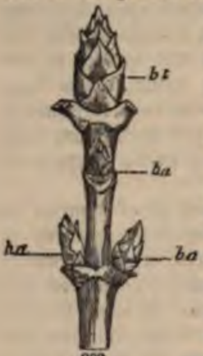
178. The spiral arrangement of the leaves allows all of them to be equally exposed to air and light, and thus enables them to carry on their functions with vigour. The form of the stem is also probably connected with the leaf arrangement. M. Cagnat has remarked that an analogy in arrangement of leaves and character of stem may be traced. The leaves of juniper are in verticils of three, and the pith is triangular; the leaves of cypress being opposite, the pith presents the form of a cross. When leaves are opposite and decussate, the stems are often square, as in Labiate plants. The ordinary rounded stem appears to be associated with a certain degree of alternation in the separate leaves, or in the different pairs of leaves when they are opposite.

179. The study of the structure, forms, and arrangement of leaves, is of great importance, when it is considered that all parts of plants are to be looked upon as leaf-formations variously modified, in order to serve special purposes in the economy of vegetation. The morphological relations of leaves, or the varied forms which they assume, will be illustrated during the consideration of the organs of reproduction, and of the doctrine of metamorphosis, as propounded by Goethe and others. It is only by looking upon all the organs of plants in their relation to the leaf as a type, that a philosophical view can be given of the great plan on which they have been formed.

Leaf-buds.

180. **Leaf-buds** contain the rudiments of branches, and are found in the *axil* of previously-formed leaves (fig. 202 *ba*, *ba*, *ba*); or, in other words, in the angle formed between the stem and leaf. They are hence called *axillary*, and may be either *terminal*, *b t*, or lateral, *b a*. In their commencement, they are cellular prolongations from the medullary rays bursting through the bark. The central cellular portion is surrounded by spiral vessels, and is covered with rudimentary leaves. In the progress of growth, vascular bundles are formed continuous with those of the stem; and, ultimately, branches are produced which in every respect resemble the axis whence the buds first sprung. The cellular portion in the centre remains as pith

with its medullary sheath, which is closed and not continuous with that of the parent stem. Thus, in the stem and branch, this sheath forms a canal which is closed at both extremities, and which sends prolongations of spiral vessels to the leaves. As the axis or central portion of the leaf-bud increases, cellular projections appear at regular intervals, which are the rudimentary leaves.



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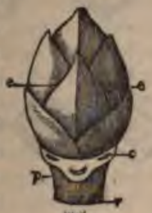
181. A leaf-bud may be removed in a young state from one plant and grafted upon another, by the process of *budding*, so as to continue to form its different parts; and it may even be made to grow in the soil, in some instances, immediately after removal. In certain cases, leaf-buds are naturally detached during the life of the parent, so as to form independent plants, and thus propagate the individual. Leaf-buds have on this account been called *fixed embryos*, by Petit-Thouars and others. They are embryo plants fixed to the axis, capable of sending stems and leaves in an upward direction, and woody fibres downwards, which, according to some, may be considered as roots. A tree may be said to consist of a series of leaf-buds, or *phytons* (φυτὸν, a plant), attached to a common axis or trunk. In ordinary trees, in which there is provision made for the formation of numerous lateral leaf-buds, any injury done to a few branches is easily repaired; but in Palms, which only form central leaf-buds, and have no provision for a lateral formation of them, an injury inflicted on the bud in the axis is more likely to have a prejudicial effect on the future life of the plant.

182. In the trees of temperate and cold climates, the buds which are developed during one season lie dormant during the winter, ready to burst out under the genial warmth of spring. They are generally protected by external modified leaves in the form of *scales*, *tegmenta* or *perulæ* (*tegmenta*, coverings, *perulæ*, small bags), which are of a firmer and coarser texture than the leaves themselves. These scales or protective appendages of the bud, consist either of the altered laminæ, or of the enlarged petiolary sheath, or of stipules, as in the Fig and Magnolia, or of one or two of these parts combined. They serve a temporary purpose, and usually fall off sooner or later after the leaves are expanded. The bud is often protected by a coating of resinous matter, as in the Horse-chestnut and Balsam poplar, or by a thick downy covering, as in the Willow. Linnæus called leaf-buds *hibernacula*, or the *winter quarters* of the young branch.

183. In the bud of a common tree, as the Sycamore (fig. 203),

Fig. 202.—Upper portion of a branch of Lonicera nigra in a state of hibernation, that is to say, after the fall of the leaves; covered with leaf-buds. *b t*, A terminal bud. *b a*, *b a*, *b a*, Axillary lateral buds. Below the buds, the cicatrix or scar left by the fallen leaves is seen.

there is seen the cicatrix left by the leaf of the previous year, *c*, with the pulvinus or swelling, *p*, then the scales, *e e*, arranged alternately in a spiral manner, and overlying each other in what is called an *imbricated* (*imbrex*, a roof tile) manner. On making a transverse section of the bud (fig. 204), the overlying scales, *e e e e*, are distinctly seen surrounding the leaves, *f*, which are plaited or folded round the axis or growing point. In plants of warm climates, the buds are often formed by the ordinary leaves without any protecting appendages; such leaves are called *naked*.



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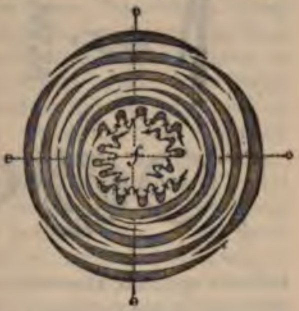

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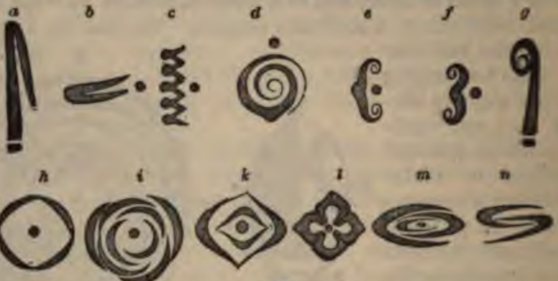
184. **Vernation.**—The arrangement of the leaves in the bud has been denominated *vernation* (*ver*, spring), or *præfoliation* (*præ*, before, and *folium*, leaf), or *gemmation* (*gemma*, a bud). This differs in different plants, but in each species it follows a regular law. The leaves in the bud are either placed simply in apposition, as in the Mistletoe, or they are folded or rolled up longitudinally or laterally, giving rise to different kinds of vernation, as delineated in fig. 205 *a*—*n*, where the *dot* represents the axis, and the folded or curved lines, the leaves with the thickened part indicating the midrib; figs. *a* and *g*, being vertical sections; *b*—*f* and *h*—*n*, horizontal.

185. The leaf taken individually, is either folded longitudinally from apex to base (fig. 205 *a*), as in the Tulip-tree, and called *reclinate*; or rolled up in a circular manner from apex to base, as in Ferns (fig. 205 *g*), and called *circinate* (*circino*, I turn round); or folded laterally, *conduplicate*, as in Oak (fig. 205 *b*); or it has several folds like a fan, *plicate* or *plaited*, as in Vine and Sycamore (figs. 204 *f*, 205 *c*), and in leaves with radiating venation, where the ribs mark the foldings; or it is rolled upon itself, *convolute* or *supervolute*, as in Banana and Apricot (fig. 205 *d*); or its edges are rolled inwards, *involute*, as in Violet (fig. 205 *e*); or outwards, *revolute*, as in Rosemary (fig. 205 *f*). The different divisions of a cut leaf may be folded or rolled up separately, as in Ferns, while the entire leaf may have either the same or a different kind of vernation.

Fig. 203.—Leaf-bud of Acer pseudo-platanus covered with scales. *r*, The branch. *p*, Pulvinus or swelling at the base of the leaf which has fallen, leaving a scar or cicatricula, *c*, in which the remains of three vascular bundles are seen. *e e*, Imbricated scales of the bud.

Fig. 204.—Transverse section of the same leaf-bud. *e e e e*, The scales arranged in an imbricated manner, like the tiles on a house. *f*, The leaves folded in a plaited manner, exhibiting plicate vernation.

186. Other kinds of vernation receive their names from the arrangement of the leaves in the bud, taken as a whole. Leaves in the bud are opposite, alternate, or verticillate; and thus different kinds of vernation are produced. Sometimes they are nearly in a circle at the same level, remaining flat, or only slightly convex externally, and placed so as to touch each other by their edges; thus giving rise to *valvate* vernation (fig. 205 *h*). At other times they are at different levels, and are applied over each other, so as to be *imbricated*, as in Lilac, and in the outer scales of Sycamore (figs. 203, 204); and occasionally the margin of one leaf overlaps that of another, while it, in its turn, is overlapped by a third, so as to be *twisted* or *spiral* (fig. 205 *i*). When the leaves are more completely folded, they either touch at their extremities (fig. 205 *k*), or are folded inwards by their margin, and become *induplicate* (fig. 205 *l*); or a conduplicate leaf covers another similarly folded, while it covers a third, and thus the vernation is *equitant* (riding), as in Privet (fig. 205 *m*); or conduplicate leaves are placed, so that the half of the one covers the half of another, and thus they become *half-equitant* or *obvolute*, as in Sage (fig. 205 *n*). The scales of a bud sometimes exhibit one kind of vernation, and the leaves another (fig. 204). The same modes of arrangement occur in the flower-buds, as will be afterwards shown.



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187. Leaf-buds, as has been stated, are either terminal or lateral. By the production of the former (fig. 202 *b t*), stems increase in length, while the latter (fig. 202 *b a*, *b a*, *b a*) give rise to branches, and add to the diameter of the stem. The terminal leaf-bud, after producing leaves, sometimes dies at the end of one season, and the

Fig. 205.—Figures to show the different kinds of vernation. *a*—*g*, The folding of individual leaves; *a* and *g* being vertical sections, *b c d e* and *f*, being horizontal. *a*, Reclinate. *b*, Conduplicate. *c*, Plicate. *d*, Convolute. *e*, Involute. *f*, Revolute. *g*, Circinate. *h*—*n*, Folding of leaves when united together in the leaf-bud. The sections are horizontal or transverse, and show the relative position of the leaves, and the mode in which each of them is folded. *h*, Valvate. *i*, Twisted or spiral. *k*, Opposite or accumbent, with the margins reduplicate. *l*, Induplicate. *m*, Equitant. *n*, Obvolute or half-equitant. In all the figures, the thickened portion indicates the midrib of the leaf and the dot marks the position of the axis.

whole plant, as in annuals, perishes; or part of the axis is persistent, and remains for two or more years, each of the leaves before its decay producing a leaf-bud in its axil. This leaf-bud continues the growth in spring.

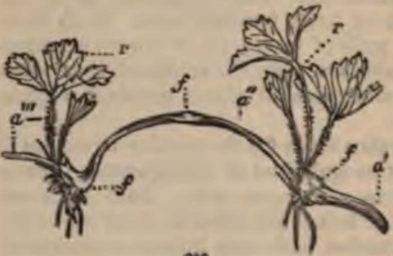
188. In some trees of warm climates, as Cycas, Papaw-tree, Palms, and Tree ferns, the production of terminal buds is well seen. In these plants, the elongation of the stem is generally regular and uniform, so that the age of the plant may be estimated by its height. Such stems (often endogenous) may thus be considered as formed by a series of terminal buds, placed one over the other. From this mode of growth they do not attain a great diameter (fig. 115, 1). In other trees, especially Exogens, besides the terminal bud there are also lateral ones. These, by their development, give rise to *branches (rami)*, from which others called *branchlets* or *twigs* (*ramuli*) arise. Such buds being always produced in the axils of leaves, are of course arranged in the same manner as the leaves are. By the continual production of lateral leaf-buds, the stem of exogenous plants acquires a great diameter.

189. Although provision is thus made for the regular formation of leaf-buds, there are often great irregularities in consequence of many being abortive, or remaining in a dormant state. Such buds are called *latent*, and are capable of being developed in cases where the terminal bud, or any of the branches, have been injured or destroyed. In some instances, as in Firs, the latent buds follow a regular system of alternation; and in plants with opposite leaves, it frequently happens that the bud in the axil of one of the leaves only is developed, and the different buds so produced are situated alternately on opposite sides of the stem.

190. When the terminal leaf is injured or arrested in its growth, the elongation of the main axis stops, and the lateral branches often acquire increased activity. By continually cutting off the terminal buds, a woody plant is made to assume a bushy appearance, and thus *pollard* trees are produced. Pruning has the effect of checking the growth of terminal buds, and of causing lateral ones to push forth. The peculiar bird-nest appearance often presented by the branches of the common Birch, depends on an arrestment in the terminal buds, a shortening of the internodes, and a consequent clustering or fasciculation of the twigs. In some plants there is a natural arrestment of the main axis after a certain time, giving rise to peculiar shortened stems. Thus the crown of the root (¶ 70) is a stem of this nature, forming buds and roots. Such is also the case in the stem of Cyclamen, Testudinaria elephantipes, and in the tuber of the potato. The production of lateral in place of terminal buds, sometimes gives the stem a remarkable zigzag aspect.

191. In many plants with a shortened axis, the lateral buds produce

long branches. Thus the *flagellum* (*flagellum*, a whip or twig), or *runner* of the Strawberry and Ranunculus, is an elongated branch, developing buds as it runs along the ground; the *propagulum* (*propago*, a shoot), or *offset*, is a short thick branch produced laterally in fleshy plants from a shortened axis, and developing a bud at its extremity, which is capable of living when detached, as in Houseleek. Fig. 206 represents a strawberry plant in which a' is the primary axis, ending in a cluster of green leaves, *r*, and some rudimentary leaves, *f*, and not elongating; from the axil of one of the leaves proceeds a branch or runner, a'', with a rudimentary leaf, *f*, about the middle, and another cluster of leaves, *f* and *r*, forming a young plant with roots; from this a third axis comes off, a''', and so on. In many instances the runner decays, and the young plant assumes an independent existence. Gardeners imitate this in the propagation of plants by the process of *layering*, which consists in bending a twig, fixing the central part of it into the ground, and, after the production of adventitious roots, cutting off its connection with the parent.



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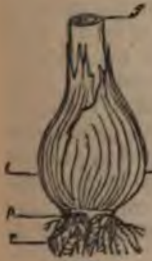
192. When the stem creeps along the surface of the ground, as in the Rhizome (fig. 90), or completely under ground, as in the Soboles or creeping stem (fig. 91), the terminal bud continues to elongate year after year, thus making additions to the axis in a horizontal manner. At the same time buds are annually produced on one side which send shoots upwards and roots downwards. Thus, in fig. 91 (soboles of a Rush), *r* is the extremity of the axis or terminal bud, *f f* the leaves in the form of scales, *p a* the aerial shoots or branches, *t t* being the level of the ground. Again, in fig. 90 (rhizome of Solomon's seal), *a* is the terminal bud which has been formed subsequently to *b*, *b* the bud which has sent up leaves, and which has decayed, *c c* being the scars left by the similar buds of previous seasons.

193. **Aerial and Subterranean Leaf-buds.**—According to the nature of the stems, leaf-buds are either *aerial* or *subterranean*; the former occurring in plants which have the stems above ground, the latter in those in which the stems are covered. In the case of Asparagus and other plants which have a perennial stem below ground, sub-

Fig. 206.—Flagellum, or Runner of the Strawberry. a', One axis which has produced a cluster of leaves, the upper, *r*, green, the lower, *f*, rudimentary. From the axil of one of the latter, a second axis, a'', arises, bearing about the middle a rudimentary leaf, *f*, and a cluster of leaves, *r*, partly green, and partly rudimentary, at its extremity. From the axil of one of the leaves of this cluster, a third axis, a''', proceeds.

terranean buds are annually produced, which appear above ground as shoots or branches covered with scales at first (fig. 110 *l*), and ultimately with true leaves. The young shoot is called a *Turio* (*turio*, a young branch). These branches are herbaceous and perish annually, while the true stem remains below ground ready to send up fresh shoots next season. In Bananas and Plantains, the apparent aerial stem is a shoot or leaf-bud sent up by an underground stem, and perishes after ripening fruit. In some plants, several branches are sent up at once from the underground stem, in consequence of a rapid development of lateral as well as terminal buds; and in such cases the lateral ones may be separated as distinct plants in the form of *suckers* (surculi). The potato is a thickened stem or branch capable of developing leaf-buds, which in their turn form aerial and subterranean branches, the former of which decay annually, while the latter remain as *tubers* to propagate the plant. Thus, in fig. 92, *s s* is the surface of the soil, *p a* is the aerial portion of the potato covered with leaves, *t* is the subterranean stem or tuber covered with small scales or projections, as represented at T *b*, from the axil of which leaf-buds are produced. This provision for a symmetrical development of axillary leaf-buds at once distinguishes the tuber of the potato from fleshy roots, like those of the Dahlia.

194. **Bulb.**—A good example of a subterranean bud occurs in the *Bulb*, as seen in the Hyacinth, Lily, and Onion. This is a subterranean leaf-bud covered with scales, arising from a shortened axis. From the centre of the bulb a shoot or herbaceous stem is produced which dies



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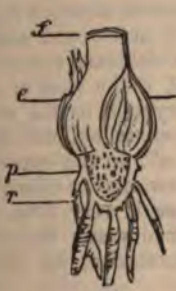

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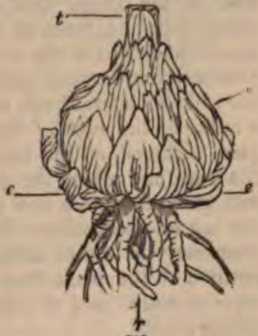

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Fig. 207.—Tunicated bulb of Allium Porrum, or the Leek. *r*, Roots. *p*, A circular disc, or shortened stem intervening between the roots and the bulbous swelling. *e e*, Scales, or subterranean modified leaves. *f*, Upper leaves which become green.

Fig. 208.—Vertical section of the tunicated bulb of the Leek. The letters indicate the same parts as in the last figure. *b*, Bud situated in the axil of a scale, which, by its development, forms a new bulb.

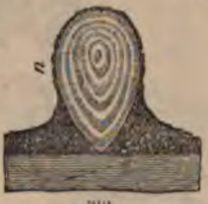
Fig. 209.—Scaly or naked bulb of Lilium album. *r*, Roots. *e e e*, Scales or modified underground leaves. *t*, The stem cut.

down. New bulbs, or *cloves* as they are called, are produced from the subterranean axis. At the base of the scales there is a flattened disc, varying in thickness, which is formed by the base of the buds, and which has sometimes been called the stem. The parts of the bulb are seen in fig. 207, where *p* marks the disc or round flat portion formed by the bases of the lateral buds from which the fasciculated roots, *r*, proceed, *e* the scales or modified leaves, and *f* the true leaves. In the vertical section (fig. 208), *b* is the new bulb formed like a bud in the axil of a scale. The new bulb sometimes remains attached to the parent bulb, and sends up an axis and leaves; at other times it is detached in the course of growth, and forms an independent plant. The new bulbs feed on the parent one, and ultimately cause its absorption. The scales are sometimes all fleshy, as in the *scaly* or *naked bulb* of the white lily (fig 209 *e e e*), or the outer ones are thin and membranous, overlapping the internal fleshy ones, and forming a *tunicated bulb*, as in the Onion, Squill, and Leek (fig. 207).

195. The **Corm** (κορμός, a stump) has already been noticed under the head of subterranean stems (¶ 70, fig. 93). It may be considered as a bulb in which the central portion or axis is much enlarged, while the scales are reduced to thin membranes. Some have called it a *solid bulb*. A Corm may be generally distinguished from a Bulb, by a transverse section of the latter presenting a series of circles, equal in number to the fleshy scales arranged around its central axis. It is seen in the Tulip, Colchicum, Crocus, and Gladiolus. It produces either terminal buds, as in Gladiolus and Crocus, in which several annual additions to the corm remain attached together, and the newly produced corms come gradually nearer and nearer to the surface of the soil; or lateral buds, as in Colchicum, represented at fig. 93, where *r* indicates the roots, *f* the leaf, *a′* the stem or axis of the preceding year withered, *a″* the secondary axis, or the stem developed during the year, and taking the place of the old one, and which, in its turn, will give origin to a new axis, *a‴*, on the opposite side, according to the law of alternation. The new axes or corms being thus produced alternately at either side, there is very little change in the actual position of the plant from year to year. Bulbs and corms contain a store of starch and of other substances, for the nourishment of the young plants.

196. **Anomalies and Transformations of Leaf-buds.**—Leaf-buds arise from the medullary system of the plant, and in some instances they are found among the cellular tissue, without being in the axil of leaves. In this case they are *extra-axillary*, and have been called *adventitious* or *abnormal*. Such buds are produced after the stem and leaves have been formed, and in particular circumstances they are developed like normal buds. What have been called *embryo-buds*, are woody nodules seen in the bark of the Beech, Elm, and other trees. They are looked

upon as partially developed abnormal buds, in which the woody matter is pressed upon by the surrounding tissue, and thus acquires a very hard and firm texture. When a section is made, they present woody circles arranged around a central pith, and traversed by medullary rays (fig. 210). The nodules sometimes form *knots* on the surface of the stem, at other times they appear as large *excrescences*, and in some cases twigs and leaves are produced by them. Some consider embryo-buds as formed by layers of woody matter, which originate in the sap conveyed downward by the bark and cambium cells, and are deposited round a nucleus or central mass.



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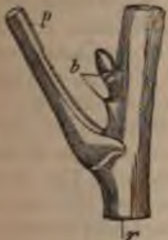
197. Leaf-buds sometimes become extra-axillary (fig. 211 *b*), in consequence of the non-appearance or abortion of one or more leaves, or on account of the adhesion of the young branch to the parent stem. In place of one leaf-bud, there are occasionally several accessory ones produced in the axil, giving origin to numerous branches (fig 212 *b*). Such an occurrence is traced to the presence of latent or adventitious buds. Fig. 211 represents a branch *r*, of walnut, *p* the cut petiole, and *b* two buds, of which the upper is most developed, while fig. 212 exhibits a branch of Lonicera tartarica, with numerous buds, *b*, in the axil of the leaves, the lowest of which are most advanced. By the union of several such leaf-buds, branches are produced having a thickened or flattened appearance, as is seen in the Fir, Ash, and other trees. These *fasciated* (*fascia*, a band) branches, in some cases, however, are owing to the abnormal development of a single bud.



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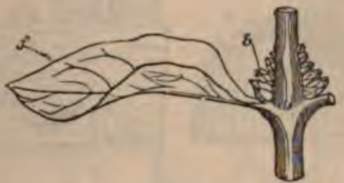

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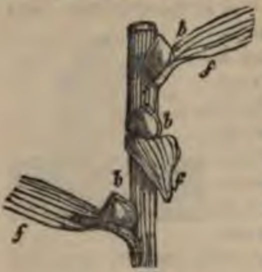
Fig. 210.—Vertical section of a nodule, *n*, or embryo-bud embedded in the bark of the Cedar. It forms a projection on the surface. The woody layers form zones round a kind of pith.

Fig. 211.—Portion of a branch, *r*, of the walnut, bearing the petiole, *p*, of a leaf which has been cut. In the axil of the leaf, several buds, *b*, are produced, the highest of which are most developed.

Fig. 212.—Portion of a branch, *r*, of Lonicera tartarica, bearing two opposite leaves, one of which has been cut, the other, *f*, being preserved. In the axil of the leaves, clusters of buds, *b*, are seen, the lowest of which are most developed.



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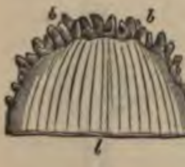
198. In the axil of the leaves of Lilium bulbiferum, Dentaria bulbifera, and some other plants, small conical or rounded bodies are produced called *bulbils* or *bulblets* (fig. 213 *b b b*). They resemble bulbs in their aspect, and consist of a small number of thickened scales enclosing a growing point. These scales are frequently united closely together so as to form a solid mass. Bulbils are therefore transformed leaf-buds, which are easily detached, and are capable of producing young plants when placed in favourable circumstances.

199. Occasionally leaf-buds are produced naturally on the edges of leaves, as in Bryophyllum calycinum and Malaxis paludosa (fig. 214), and on the surface of leaves, as in Ornithogalum thyrsoideum (fig. 215). These are capable of forming independent plants. Similar buds are also made to appear on the leaves of Gesnera, Gloxinia, and Achimenes, by wounding various parts of them, and placing them in moist soil; this is the method often pursued by gardeners in their propagation. The cellular tissue near the surface of plants, seems therefore to have the power of developing abnormal leaf-buds in certain circumstances. Even roots, when long exposed to the air, may thus assume the functions of stems. Leaves bearing buds on their margin, are called *proliferous* (*proles*, offspring, and *fero*, I bear).



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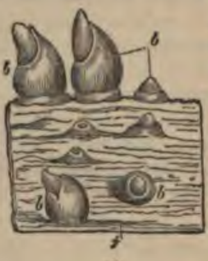

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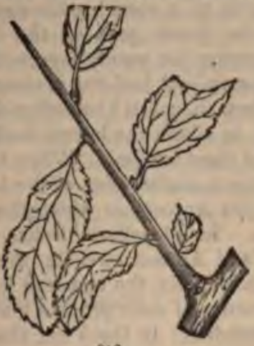
200. **Spines or Thorns.**—Branches are sometimes arrested in their development, and, in place of forming leaves, become transformed into *spines* and *tendrils*. Spines or thorns are undeveloped branches, ending in more or less pointed extremities, as in the Hawthorn. Plants which have spines in a wild state, as the Apple and Pear, often lose them when cultivated, in consequence of their being changed into branches; in some cases, as in Prunus spinosa, or the Sloe (fig. 216), a branch

Fig. 213.—Portion of the stem of Lilium bulbiferum with three alternate leaves, *f f f*, and three bulbils or bulblets, *b b b*, in their axils.

Fig. 214.—Extremity of a leaf, *l*, of Malaxis paludosa, the margin of which is covered with adventitious buds, *b b*; thus becoming proliferous.

Fig. 215.—Portion of the blade of a leaf, *f*, of Ornithogalum thyrsoideum, on the surface of which are developed adventitious or abnormal buds, *b b b b*, some of which are large.

bears leaves at its lower portions, and terminates in a spine. Leaves themselves often become spiny by the hardening of their midrib or primary veins, and the diminution or absence of parenchyma, as in Astragalus massiliensis (fig. 217 *r*), where the midrib becomes spiny after the fall of some of the leaflets; in the Holly, where all the veins are so; and in the Barberry (fig. 218), where some of the leaves, *f f f*, are produced in the form of spiny branches, with scarcely any parenchyma. In place of producing a lamina or blade at its extremity, the petiole sometimes terminates in a spine. Stipules are occasionally transformed into spines, as in Robinia pseudo-acacia (fig. 219, *s s*), and such is also the case with the swelling or pulvinus at the base of the leaf, as in Ribes Uva-crispa (fig. 220, *c c c*). Branches are sometimes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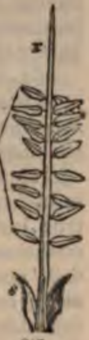

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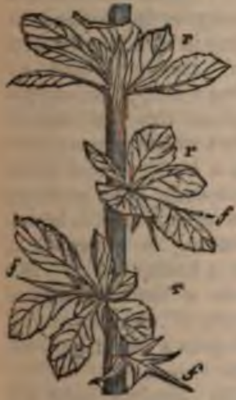

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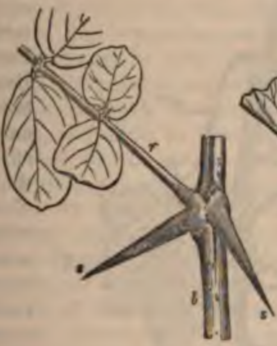

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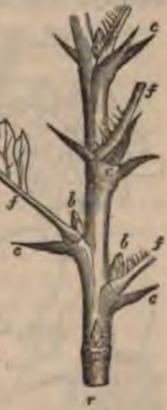

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Fig. 216.—Branch of Prunus spinosa, or Sloe, with alternate leaves, and ending in a spine or thorn.

Fig. 217.—Pinnate leaf of Astragalus massiliensis, the midrib of which, *r*, ends in a spine. *s*, Petiolary stipules. *f*, Nine pairs of leaflets.

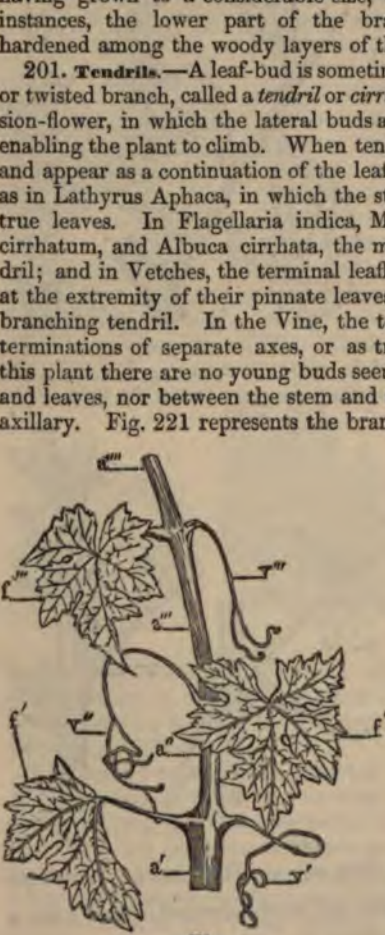
Fig. 218.—Branch of Berberis vulgaris, or Barberry, the leaves of which, *f f f*, are transformed into branching spines. In the axil of each, a cluster, *r r r*, of regularly formed leaves is developed.

Fig. 219.—Base of the pinnate leaf of Robinia pseudo-acacia, the stipules of which, *s s*, are converted into spines or thorns. *b*, Branch. *r*, Petiole.

Fig. 220.—Branch of Ribes Uva-crispa, in which the pulvinus or swelling, *c c c*, at the base of each of the leaves, *f f f*, is changed into a spine, which is either simple, or double, or triple. *b b*, Leaf-buds arising from the axil of the leaves.

arrested in their progress at an early state of their development, and do not appear beyond the surface of the stem; at other times, after having grown to a considerable size, they undergo decay. In both instances, the lower part of the branch becomes embedded and hardened among the woody layers of the stem, and forms a *knot*.

201. **Tendrils.**—A leaf-bud is sometimes developed as a slender spiral or twisted branch, called a *tendril* or *cirrhus* (*cirrus*, a curl), as in the Passion-flower, in which the lateral buds are thus altered with the view of enabling the plant to climb. When tendrils occupy the place of leaves, and appear as a continuation of the leaf-stalk, they are called *petiolary*, as in Lathyrus Aphaca, in which the stipules perform the function of true leaves. In Flagellaria indica, Methonica superba, Anthericum cirrhatum, and Albuca cirrhata, the midrib of the leaf ends in a tendril; and in Vetches, the terminal leaflet, and some of the lateral ones at the extremity of their pinnate leaves, are changed, so as to form a branching tendril. In the Vine, the tendrils are looked upon as the terminations of separate axes, or as transformed terminal buds. In this plant there are no young buds seen in the angle between the stem and leaves, nor between the stem and tendrils; and the latter are not axillary. Fig. 221 represents the branch of a Vine, in which *a'* is the primary or first formed axis, ending in *v'*, a tendril or altered terminal bud, and having a leaf, *f'*, on one side. Between this leaf and the tendril which represents the axis, a leaf-bud was formed at an early date producing the secondary axis, or branch, *a''*, ending in a tendril, *v''*, with a lateral leaf, *f''*, from which a tertiary axis or branch, *a'''*, was developed, ending in a tendril *v'''*, and so on.



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202. Tendrils twist in a spiral manner, and enable the plants to rise into the air by twining round other plants. The direction of the spiral frequently differs from

Fig. 221.—Portion of a branch of the Vine (*Vitis vinifera*). *a'*, First axis, terminated by a tendril or cirrhus, *v'*, which assumes a lateral position, and bears a leaf, *f'*. From the axil of this leaf, a second axis, *a''*, comes off, which seems to be a continuation of the first, and is terminated also by a tendril, *v''*, bearing a leaf, *f''*. From the axil of this second leaf, a third axis, *a'''*, arises, terminated by a tendril, *v'''*, and bearing a leaf, *f'''*, from the axil of which a fourth axis, *a''''*, arises.

that of the climbing stem, producing the tendril. In the Vine, the lower part of the stem is strong, and needs no additional support; the tendrils therefore occur only in the upper part where the branches are soft, and require aid to enable them to support the clusters of fruit. In Vanilla aromatica, the vanille plant, tendrils are produced opposite the leaves, until the plant gains the top of the trees by which it is supported; the upper tendrils being then developed as leaves. The midrib is sometimes prolonged in a cup-like form: this is occasionally seen in the common cabbage, and seems to depend on the vascular bundles of the midrib spreading out at their extremity in a radiating manner, and becoming covered with parenchyma in such a way as to form a hollow cavity in the centre.

Special Functions of Leaves.

203. Leaves expose the fluids of the plant to the influence of air and light, and their spiral arrangement enables them to do so effectually. They are concerned in the elaboration of the various vegetable secretions, in the formation of wood, and in the absorption of fluid and gaseous matters. A plant, by being constantly deprived of its leaves, will ultimately be destroyed. On this principle, weeds, with creeping stems and vigorous roots, which are with difficulty eradicated, may be killed. In the cells of the leaves changes take place under the agency of light, by which oxygen is given off and carbon fixed. These will be considered under the head of vegetable *respiration*. The absorption of carbonic acid and of fluids is carried on by the leaves, chiefly through their stomata, according to Bonnet, who found that absorption was rapidly effected by the under surface of ordinary leaves in which the cuticle is thinnest, cellular tissue least condensed, and stomata most abundant; the upper surface of the leaf usually presenting a polished and dense epidermis, and having few stomata, taking little part in such a process. Hoffman[*] has carried these researches farther, and ascertained that leaves absorb fluids in large quantities; that during a fall of rain the vegetable fluids undergo from such a cause a process of dilution, leading to an immediate and more rapid descent of sap, which under such circumstances is capable of general diffusion throughout the several vegetable tissues. Some physiologists have expressed doubts as to absorption being carried on by the leaves in ordinary circumstances. Leaves, it has been shown, absorb gaseous matters. Saussure states that oxygen is absorbed by the leaves during night, the quantity varying according to the nature of the plant. Boussingault[†] has found that the leaves of the Vine absorb carbonic acid from the air. Other experiments prove that

[*] Hoffman on Circulation of Sap, Scientific Memoirs. Nat Hist. i. 46.

[†] Boussingault, Economie Rurale, i. 66.

ammonia and nitrogen are similarly acted on. Leaves also give off gases and fluids by a process of exhalation or transpiration. Carbonic acid, to a moderate extent, is exhaled during darkness, and a large quantity of fluid is given off by transpiration. The number and size of the stomata regulate the transpiration of fluids, and it is modified by the nature of the epidermis. The absorbing power of leaves depending on similar causes, is capable of being increased by any process which removes either natural or imposed obstructions to the free action of their surface. It is thus that rain, while supplying the material for absorption, at the same time renders the leaf more capable of such action. In plants with a thick and hard epidermal covering, exhalation is less vigorous than in those where it is thin and soft. Some succulent plants of warm climates have a very thick covering. The peculiar character of the leaves or phyllodia of Australian plants, is probably connected with the dry nature of the climate. While heat acts in promoting evaporation, the process of transpiration is more under the influence of light. It assists the process of endosmose, by rendering the fluid in the cells thicker, and thus promotes the circulation of sap.

204. The quantity of fluid exhaled varies in amount in different plants. A Sunflower three feet high, gave off twenty ounces of watery fluid daily. Hales found that a Cabbage, with a surface of 2,736 square inches, transpired at an average nineteen ounces; a Vine, of 1,820 square inches, from five to six ounces. Experiments on exhalation may be made by taking a fresh leaf with a long petiole, putting it through a hole in a card which it exactly fits, and applying the card firmly and closely to a glass tumbler, about two-thirds full of water, so that the petiole is inserted into the water, then inverting an empty tumbler over the leaf, and exposing the whole to the sun, the fluid exhaled will be seen on the inside of the upper tumbler. The experiment may be varied by putting the apparatus in darkness, when no exhalation takes place, or in diffuse daylight, when it is less than in the sun's rays. This process of exhalation imparts moisture to the atmosphere, and hence the difference between the air of a wooded country and that of a country deprived of forests. The cells in the lower side of a leaf where stomata exist, are chiefly concerned in the aeration of the sap, whilst other assimilative processes go on in the upper cells.

205. Leaves, after performing their functions for a certain time, wither and die. In doing so, they frequently change colour, and hence arise the beautiful and varied tints of the autumnal folinge. This change of colour is chiefly occasioned by the diminished circulation in the leaves, and the higher degree of oxidation to which their chlorophylle has been submitted. Leaves which are articulated with the stem, as in the Walnut and Horse-chestnut, fall and leave a scar,

while those which are continuous with it remain attached for some time after they have lost their vitality, as in the Beech. Most of the trees of this country have deciduous leaves, their duration not extending over more than a few months; while in trees of warm climates, the leaves often remain for two or more years. In tropical countries, however, many trees lose their leaves in the dry season. This is seen in the forests of Brazil, called *Catingas*. The period of defoliation varies in different countries according to the nature of their climate. Trees which are called evergreen, as Pines and Evergreen oak, are always deprived of a certain number of leaves at intervals, sufficient being left, however, to preserve their green appearance. Various causes have been assigned for the fall of the leaf. In cold climates, the deficiency of light and heat in winter causes a cessation in the functions of the cells of the leaf; its fluid disappears by evaporation; its cells and vessels become contracted and diminished in their calibre; various inorganic matters accumulate in the texture; the whole leaf becomes dry; its parts lose their adherence; and it either falls by its own weight or is detached by the wind. In warm climates, the dry season gives rise to similar phenomena.

SECTION II.—GENERAL VIEW OF THE FUNCTIONS OF THE NUTRITIVE ORGANS.

206. In order that plants may be nourished, food is required. This food, in a crude state, enters the roots by a process of *absorption* or *imbibition;* it is then transmitted from one part of the plant to another, by means of the *circulation* or *progressive movement of the sap;* it reaches the leaves, and is there submitted to the action of light and air, which constitutes the function of *respiration;* and thus the fluids are finally fitted for the process of *assimilation*, and form various vegetable *products* and *secretions.*

1.—FOOD OF PLANTS AND SOURCES WHENCE THEY DERIVE THEIR NOURISHMENT. CHEMICAL COMPOSITION OF PLANTS.

207. The nutriment of plants can only be ascertained when their chemical composition has been determined. The physiologist and chemist must unite in this inquiry, in order to arrive at satisfactory conclusions. Much has been done of late by Liebig, Mülder, Dumas, Boussingault, and other chemists, to aid the botanist in his investigations, and to place physiological science on a sound and firm basis.

It is true that many processes take place in plants which cannot as yet be explained by the chemist, and to these the name of *vital* has been applied. This term, however, must be considered as implying nothing more than that the function so called occurs in living bodies, and in the present state of our knowledge is not reducible to ordinary chemical or physical laws. A greater advance in science may clear up many difficulties in regard to some of the vital functions, while others may ever remain obscure.

208. Plants are composed of certain *chemical elements*, which are necessary for their growth. These are combined in various ways, so as to form what have been called *organic* and *inorganic* compounds. The former are composed of carbon, oxygen, hydrogen, and nitrogen or azote, with a certain proportion of sulphur and phosphorus; while the latter consist of various metallic bases, combined wtth oxygen, metalloids, and acids. In all plants there is a greater or less proportion of water, the quantity of which is ascertained by drying at a temperature a little above that of boiling water. By burning the dried plant the organic constituents disappear, and the inorganic part or the ash is left. The relative proportion of these constituents varies in different species, as seen in the following table by Solly, in which the proportions are given in 10,000 parts of the fresh plants:—

	Water.	Organic Matter.	Inorganic.
Potato,	7713	2173	114
Turnip,	9308	588	104
Sea Kale,	9238	705	57
French Beans,	9317	619	64
Red Beet,	8501	1390	109
Asparagus,	9210	735	55
Water Cress,	9260	633	107
Sorrel,	9207	702	91
Parsley,	8430	1299	271
Fennel,	8761	1048	191
Salsafy,	7951	1929	120
Mustard,	9462	436	102

209. The analysis of 100 parts of Fruits gives the following results:—

	Water.	Organic.	Inorganic.
Strawberry,	90·22	9·37	0·41
Green Gage, whole fruit,	83·77	15·83	0·40
Cherry, do.	82·48	17·09	0·43
Pear, do.	83·55	16·04	0·41
Apple, do.	84·01	15·72	0·27
ooseberry,	90·26	9·35	0·39

The following table, by Johnston, represents the constitution in rts of plants and seeds, taken in the state in which they are given to cattle, or laid up for preservation, and dried at 230° Fahrenheit; the organic matter being indicated by the carbon, oxygen, hydrogen, and nitrogen; the inorganic by the ash:—

	Wheat.	Oats.	Peas.	Hay.	Turnips.	Potatoes.
Carbon	455	507	465	458	429	441
Hydrogen	57	64	61	50	56	58
Oxygen	430	367	401	387	422	439
Nitrogen	35	22	42	15	17	12
Ash	23	40	31	90	76	50

By the process of drying, the 1000 parts of these substances lost water in the following proportions:—

Wheat, 166	Peas, 86	Turnips, 925
Oats, 151	Hay, 158	Potatoes, 722

211. As plants have no power of locomotion, it follows that their food must be universally distributed. The atmosphere and the soil accordingly contain all the materials requisite for their nutrition. These materials must be supplied either in a gaseous or a fluid form, and hence the necessity for the various changes which are constantly going on in the soil, and which are aided by the efforts of man. Plants are capable of deriving all their nourishment from the mineral kingdom. The first created plants in all probability did so, but in the present day the decaying remains of other plants and of animals are also concerned in the support of vegetation.

Organic Constituents and their Sources.

212. Carbon (C) is the most abundant element in plants. It forms from 40 to 50 per cent. of all the plants usually cultivated for food. When plants are charred the carbon is left, and as it enters into all the tissues, although the weight of the plants is diminished by the process, their form still remains. When converted into coal (a form of carbon), plants are frequently so much altered by pressure as to lose their structure, but occasionally it can be detected under the microscope. Carbon is insoluble, and therefore cannot be absorbed in its uncombined state. When united to oxygen, however, in the form of carbonic acid, it is readily taken up either in its gaseous state by the leaves, or in combination with water by the roots. The soil contains carbon (*humus*), and in some soils, as those of a peaty nature, it exists in very large quantity. The carbon in the soil is converted into carbonic acid in order to be made available for the purpose of plant-growth. Carbon has the power of absorbing gases, and in this way, by enabling certain combinations to go on, it assists in the nourishment of plants. In the atmosphere, carbonic acid is always present, averaging about $\frac{1}{2000}$ part, arising from the respiration of man and animals, combustion, and other processes. A certain atmospheric equilibrium is thus maintained, consequent on the difference in vegetable and animal respiration, the former giving out oxygen, which the latter consumes.

213. **Oxygen** (O) is another element of plants. Air contains about 21 per cent. of it. Every 9 lbs. of water contain 8 of oxygen, and it is combined with various elements, so as to form a great part of the solid rocks of the globe, as well as of the bodies of animals and man.

214. It is chiefly in its state of combination with **Hydrogen** (H), so as to form water (HO), that oxygen is taken up by plants. Hydrogen is not found in a free state in nature, and with the exception of coal, it does not enter into the composition of the mineral masses of the globe. It forms $\frac{1}{9}$ of the weight of water, and it is present in the atmosphere in combination with nitrogen. Hydrogen is also furnished by sulphuretted hydrogen, and some compounds of carbon. Carbonic acid and water existing to a large extent in the atmosphere, vegetables can thence also derive carbon, oxygen, and hydrogen, which enter so extensively into their constitution.

215. **Nitrogen** (N) is another element found in plants. It forms 79 per cent. of the atmosphere, and abounds in animal tissues. It is therefore requisite for the purposes of animal life that nitrogen be furnished in food. Those vegetables containing the greatest quantity of nitrogenous matter are the most nutritive. Animal matters, during their decay, give off nitrogen, combined with hydrogen, in the form of ammonia (NH^3), which is absorbed in large quantities by carbon, is very soluble in water, and seems to be the chief source whence plants derive nitrogen. In tropical countries where thunderstorms are frequent, the nitrogen and oxygen of the air are sometimes made to combine, so as to produce nitric acid, (NO^5) which, either in this state, or in combination with alkaline matters, furnishes a supply of nitrogen. Daubeny thinks that the ammonia and carbonic acid in the atmosphere are derived in part from volcanic actions going on in the interior of the globe. The continued fertility of the Terra del Lavoro, and other parts of Italy, is attributed by him to the disengagement of ammoniacal salts and carbonic acid by volcanic processes going on underneath; and to the same source he traces the abundance of gluten in the crops, as evidenced by the excellence of Italian macaroni.

216. Mülder maintains that the ammonia is not carried down from the atmosphere, but is produced in the soil by the combination between the nitrogen of the air, and the hydrogen of decomposing matters. The same thing takes place, as in natural saltpetre caverns of Ceylon, with this exception, that, by the subsequent action of oxygen, ulmic, humic, geic, apocrenic, and crenic acids, are formed in place of nitric acid. These acids consist of carbon, oxygen, and hydrogen, in

different proportions, and they form soluble salts with ammonia. By all porous substances like the soil, ammonia is produced, provided they are moist, and filled with atmospheric air, and are exposed to a certain temperature. It is thus, he states, that moist charcoal and humus become impregnated with ammonia.

217. These four elementary bodies then are supplied to plants, chiefly in the form of carbonic acid (CO^2), water (HO), and ammonia (NH^3). In these states of combination they exist in the atmosphere, and hence some plants can live suspended in the air, without any attachment to the soil. When a volcanic or a coral island appears above the waters of the ocean, the lichens which are developed on it are nourished in a great measure by the atmosphere, although they subsequently derive inorganic matter from the rocks, to which they are attached. Air plants, as Bromelias, Tillandsias, and Orchidaceæ, and many species of Ficus, can grow for a long time in the air. In the Botanic Garden of Edinburgh, a specimen of Ficus australis has lived in this condition for upwards of twenty years, receiving no supply of nourishment except that afforded by the atmosphere and common rain water, containing, of course, a certain quantity of inorganic matter. The following analysis was made of the leaves of this plant, in 1847, by my pupil, Mr. John Macadam:—

	Organic In 100 parts.	Inorganic In 100 parts.
Petiole of former year's growth, including midrib	82·98	17·02
Three leaves of former year's growth	86·24	13·76
Petiole of present year's growth, with midrib	92·65	7·35
Seven leaves of present year's growth	92·28	7·72

All were dried at 212° Fahrenheit.

In the Experimental Garden of Edinburgh, Mr. James M'Nab has cultivated various plants, as Strelitzia augusta, currants, gooseberries, &c., without any addition of soil, and simply suspended in the air, with a supply of water kept up by the capillary action of a worsted thread. Some of the plants have flowered and ripened fruit. These experiments show that the atmosphere and rain water contain all the ingredients requisite for the life of some plants. Boussingault, from observations made on the cultivation of Trefoil, was led to the conclusion, that under the influence of air and water, in a soil absolutely devoid of organic matter, some plants acquire all the organic elements requisite for growth. Messrs. Wiegman and Polstorf took fine quartz sand, burnt it to destroy any organic matter, digested it for sixteen hours in strong nitro-muriatic acid, and then washed it with distilled water. Various kinds of seeds, as barley, oats, vetch, clover, and tobacco, were then sown in it, and watered with distilled water, and all grew more or less.

218. The elementary bodies already mentioned, in various states of combination, constitute the great bulk of plants. They occur in the

form of binary compounds, as water and oily matters; ternary, as starch, gum, sugar, and cellulose; quaternary, as gluten, albumen, caseine, and fibrine. The latter compounds seem to require for their composition, not merely the elements already noticed, in the form of a basis, called Proteine (C^{40} H^{31} N^{5} O^{12} according to Mülder, or C^{48} H^{36} N^{6} O^{14} according to Liebig), but certain proportions of sulphur and phosphorus in addition; thus, albumen $= 10$ Pr. $+ 1$ P $+ 2$ S; fibrine $= 10$ Pr. $+ 1$ P $+ 1$ S; caseine $= 10$ Pr. $+ 1$ S. The tissues into the composition of which these proteine compounds enter, are tinged of a deep orange-yellow, by strong nitric acid. These compounds are highly important in an agricultural point of view, and the consideration of them will be resumed when treating of the application of manures.

Inorganic Constituents, and their Sources.

219. The consideration of the inorganic constituents of plants is no less important than the study of their organic elements. The organic substances formed by plants are decomposed by a moderately high temperature; they easily undergo putrefaction, especially when exposed to a moist and warm atmosphere, and they have not been formed by human art. Their inorganic constituents, on the other hand, are not so easily decomposed; they do not undergo putrefaction, and they have been formed artificially by the chemist.

220. The combustible or organic part of plants, even in a dried state, forms from 88 to 99 per cent. of their whole weight. Consequently, the ash or inorganic matter frequently constitutes a very small proportion of the vegetable tissue. It is not, however, on this account to be neglected, for it is found to be of great importance in the economy of vegetation, not merely on account of its entering directly into the constitution of various organs, but also from assisting in the production of certain organic compounds. Some of the lower tribes of cellular plants can exist apparently without any inorganic matter. Thus Mülder could not detect a particle of ash in Mycoderma vini, nor in moulds produced in large quantity by milk sugar. Deficiency of inorganic matters, however, in general injures the vigour of plants, and it will be found that, in an agricultural point of view, they require particular attention—a distinct relation subsisting between the kind and quality of the crop, and the nature and chemical composition of the soil in which it grows. It has been shown by careful and repeated experiments, that, when a plant is healthy and fairly ripens its seeds, the quantity and quality of the ash is nearly the same in whatever soil it is grown; and that, when two different species are grown in the same soil, the quantity and quality of the ash varies—the difference being greater the more remote the natural affinities of the plants are.

221. The inorganic elements of plants and their combinations, are thus given by Johnston:—

Chlorine (Cl.)	combined with	metals	forming	chlorides.
Iodine (I.)	... ...	metals	...	iodides.
Bromine (Br.)	... ..	metals	...	bromides.
Sulphur (S.)	... ...	metals	...	sulphurets.
	... ...	hydrogen	...	sulphuretted hydrogen, or hydro-sulphuric acid.
	... ...	oxygen	...	sulphuric acid.
Phosphorus (P.)	... ...	oxygen	..	phosphoric acid.
Potassium (K.)	... ...	oxygen	...	potassa.
	... ...	chlorine	...	chloride of potassium.
Sodium (Na.)	... ...	oxygen	...	soda.
	... ...	chlorine	...	chloride of sodium. (common salt.)
Calcium (Ca.)	... ...	oxygen	...	lime.
	... ...	chlorine	...	chloride of calcium.
Magnesium (Mg.)	... ...	oxygen	...	magnesia,
Aluminum (Al.)	... ...	oxygen	...	alumina.
Silica (Si.)	... ...	oxygen	...	silica.
Iron (Fe.) Manganese (Mn.) Copper (Cu.)	... ...	oxygen sulphur	... ...	oxides and sulphurets.

To these we may add Fluorine, whose presence in plants has been recently noticed by some writers. The extraordinary attraction of this element for Silica renders it a matter of impossibility to procure it in a separate state for examination. It is found in those vegetable structures in which Silica abounds, as in the stems of the Gramineæ, and Equisetaceæ.

222. The quantity of inorganic matter or ash left by plants, varies in different species, and in different parts of the same plant. The dried leaves usually contain a large quantity. Saussure found that—

Dried bark of Oak gave	60	of ash	in 1000
Dried leaves	58	...	...
Dried alburnum	4	...	...
Dried duramen	2	...	...

The dried leaves of Elm contain more than 11 per cent. of inorganic matter, while the wood contains less than 2 per cent.; the leaves of the Willow, 8 per cent., wood, 0·45; leaves of Beech, 6·69, wood, 0·36; leaves of Pitch-pine, 8·5, wood, 0·25. Thus, the decaying leaves of trees restore a large quantity of inorganic matter to the soil.

223. The following tables show the relative proportion of inorganic compounds present in the ash of plants:—

According to Sprengel, 1000 lbs. of wheat leave 11·77 lbs., and of wheat straw 35·18 lbs. of ash, consisting of—

	Grain.	Straw.
Potash	2·25	0·20
Soda	2·40	0·29
Lime	0·96	2·40
Magnesia	0·90	0·32
Alumina with trace of Iron	0·26	0·90
Silica	4·00	28·70
Sulphuric acid	0·50	0·37
Phosphoric acid	0·40	1·70
Chlorine	0·10	0·30
	11·77 lbs.	35·18 lbs.

In 1000 lbs. of the grain of the Oat, are contained 25·80 lbs., and of the dry straw 57·40 lbs. of inorganic matter, consisting of—

	Grain.	Straw.
Potash	1·50	8·70
Soda	1·32	0·02
Lime	0·86	1·52
Magnesia	0·67	0·22
Alumina	0·14	0·06
Oxide of Iron	0·40	0·02
Oxide of Manganese	0·00	0·02
Silica	19·76	45·88
Sulphuric acid	0·35	0·79
Phosphoric acid	0·70	0·12
Chlorine	0·10	0·05
	25·80 lbs.	57·40 lbs.

In 1000 lbs. of the field Bean, field Pea, and Rye-grass hay, after being dried in the air, the following is the amount of ash, and its composition:—

	Field Bean.		Field Pea.		Rye-grass.
	Seed.	Straw.	Seed.	Straw.	Hay.
Potash	4·15	16·56	8·10	2·35	8·81
Soda	8·16	0·50	7·39	—	3·94
Lime	1·65	6·24	0·58	27·30	7·34
Magnesia	1·58	2·09	1·36	3·42	0·90
Alumina	0·34	0·10	0·20	0·60	0·31
Oxide of Iron	—	0·07	0·10	0·20	—
Oxide of Manganese	—	0·05	—	0·07	—
Silica	1·26	2·20	4·10	9·96	27·72
Sulphuric acid	0·89	0·34	0·53	3·37	3·53
Phosphoric acid	2·92	2·26	1·90	2·40	0·25
Chlorine	0·41	0·80	0·38	0·04	0·06
	21·36	31·21	24·64	49·71	52·86

224. Dr. R. D. Thomson gives the following analysis of the inorganic matter in the stem and seeds of Lolium perenne:—

	Stem.	Seed.
Silica	64·57	42·28
Phosphoric acid	12·51	18·89
Sulphuric acid	—	3·12
Chlorine	—	trace.
Carbonic acid	—	3·61
Magnesia	4·01	5·31
Lime	6·50	18·55
Peroxide of Iron	0·36	2·10
Potash	8·03	4·80
Soda	2·17	1·38

225. These substances are variously combined in plants, in the form of sulphates, phosphates, silicates, and chlorides. Some plants, as Wheat, Oats, Barley, and Rye, contain a large quantity of Silica in their straw; others, such as Tobacco, Pea-straw, Meadow-clover, Potato-haulm, and Sainfoin, contain much lime; while Turnips, Beet-root, Potatoes, Jerusalem-artichoke, and Maize-straw, have a large proportion of salts of potash and soda in their composition. Sulphates and phosphates are required to supply part of the material necessary for the composition of the nutritive proteine compounds found in grain.

226. Silica abounds in Grasses, in Equisetum, and other plants, giving firmness to their stems. The quantity contained in the Bamboo is very large, and it is occasionally found in the joints in the form of Tabasheer. Reeds, from the quantity of siliceous matter they contain, are said, during hurricanes in warm climates, to have actually caused conflagrations by striking against each other. In the species of Equisetum, the silica in the ash is as follows:—

	Ash.	Silica.
Equisetum arvense	13·84	6·38
——— limosum	15·50	6·50
——— hyemale	11·81	8·75
——— Telmateia	23·61	12·00

The third of these furnishes Dutch Reed, used for polishing mahogany. The silica is deposited in a regular manner, forming an integral part of the structure of the plant. Many insoluble matters, as silica, seem to be deposited in cells by a process of decomposition. Thus, silicate of potash in a vegetable sap may be mixed with oxalic acid, by which oxalate of potash, and silicic acid will be produced, as in the cells of Grasses and Equisetum. Chara translucens has a covering of silicic acid, while C. vulgaris has one composed of silicic acid and carbonate of lime; and Chara hispida has a covering of carbonate of lime alone. Silica, the only known oxide of Silicon, contains 22·18 parts silicon, and 24 parts oxygen. It is in reality an acid, and a very powerful one. Its insolubility in water prevents the manifestation of its acid properties under ordinary circumstances. In those plants in which silica most abounds, Fluorine has also been discovered. The test for the presence of the latter rests in acting on the fluorine in its combination with silicon, by concentrated sulphuric acid, and so producing hydrofluoric acid, which possesses the property of fixing etches on glass; the glass to be engraved being coated with etching ground or wax, and the design traced in the usual way with a pointed instrument.

227. **Lime** is found in all plants, and in some it exists in large quantity. It occurs sometimes in the form of carbonate on the surface of plants. Thus, many of the Characeæ have a calcareous encrustation. The crystals or raphides (¶ 18) found in the cells of plants, have lime in their composition. In the roots of Turkey and East India Rhubarb, the crystals of oxalate of lime have been estimated at about 25 per cent., while in those of the English plant the proportion is about 10 per cent. In the Cactus tribe crystals of the same kind have been observed, the presence of which, in excessive quantity, imparts brittleness to the stem of the old plant.

228. **Soda and Potash** occur abundantly in plants. They are taken up from the soil in combination with acids. Those growing near the sea have a large proportion of soda in their composition, while those growing inland contain potash. Various species of Salsola, Salicornia, Halimocnemum, and Kochia, yield soda for commercial purposes, and are called Halophytes (ἅλς, salt, and φύτον, plant). The young plants, according to Göbel, furnish more soda than the old ones. There are certain species, as Armeria maritima, Cochlearia officinalis, and Plantago maritima, which are found both on the sea-shore, and high on the mountains removed from the sea. In the former situation they contain much soda and some iodine; while in the latter, according to Dr. Dickie, potash prevails, and iodine disappears.

229. **Iron, Manganese, and Copper,** especially the two last, exist in small quantity in plants. Iron is met in the soil either as an oxide, a sulphuret, or a carbonate. It usually occurs in the form of a peroxide. Iron when held in solution as a proto-carbonate is capable of being absorbed into the vegetable tissues. Copper was detected, by Sarzean, in coffee.

230. All these inorganic matters are derived in a state of solution from the soil, and plants are said to have, as it were, a power of selection, certain matters being taken up by their roots in preference to others. Saussure made a series of experiments on this subject, and stated that when the roots of plants were put into solutions containing various saline matters in equal proportions, some substances were taken up by imbibition in larger proportion than others. Bouchardat doubts the accuracy of Saussure's conclusions on this point. He thinks that errors arose from the excretions of the plants and other causes. He performed similar experiments with plants of Mint, which had been growing for six months in water previous to experiment, and he found that in cases of mixed salts in water, the plant absorbed

all in equal proportions. Daubeny states, that if a particular salt is not present, the plant frequently takes up an isomorphous one.

231. The differences in the absorption of solutions depend, perhaps, on the relative densities alone, and not on any peculiar selecting power in roots, for it is well known that poisonous matters are absorbed as well as those which are wholesome. The following experiments show that poisonous matters in solutions, varying from half a grain to five grains to the ounce of water, are taken up by roots, and that some substances which are poisonous to animals do not appear to act energetically upon plants:—

		Growing Plants	
Chloride of zinc,	on	beans,	quickly destroyed.
Sulphate of zinc,	...	cabbages and wheat,	
Sulphate of copper,	...	beans,	
Nitrate of copper,	...	beans,	
Acetate of copper,	...	cabbages,	
Bichloride of mercury,	...	beans, wheat, cabbages,	
Arsenious acid,	...	cabbages and wheat,	weak solutions did not destroy.
Arseniate of potash,	...	barley and cabbages,	
Acetate of lead,	...	beans,	destroyed in a few days.
Bichromate of potash,	...	cabbages, beans, barley,	destroyed unless much diluted.
Nitrate & sulphate of iron,	...	beans,	destroyed in a few days.
Chloride of barium,	...	beans,	quickly destroyed.
Nitrate of baryta,	...	cabbages and wheat,	
Nitrate of strontia,	...	beans,	plants uninjured, except solution strong.
Muriate, sulphate, and nitrate of lime,	...	beans,	improved when very diluted.
Sulphate and muriate of magnesia,	...	beans and cabbages,	injured, and if strong destroyed.
Phosphate of soda,	...	beans and cabbages,	no injury when diluted.
Chloride of sodium	...	beans and cabbages,	

232. **Rotation of Crops.**—As the inorganic materials which enter into the composition of plants vary much in their nature and relative proportions, it is evident that a soil may contain those necessary for the growth of certain species, while it may be deficient in those required by others. It is on this principle that the rotation of crops proceeds; those plants succeeding each other in rotation which require different inorganic compounds for their growth. In ordinary cases, except in the case of very fertile virgin soil, a crop, by being constantly grown in successive years on the same field, will deteriorate in a marked degree. Dr. Daubeny has put this to the test of experiment, by causing plants to grow on the same and different plots in successive years, and noting the *results*:—

		Average of 5 yrs.
Potatoes,	in the same plot	72·9 lbs. tubers.
	in different plots	92·8 — —
Flax,	same	15·0 lbs.
	different	19·9
Beans,	same	32·8
	different	34·8
Barley,	same	30·0
	different	46·5
Turnips,	same	104·0
	different	173·0
Oats,	same	28·0
	different	32·4

This shows a manifest advantage in shifting crops, varying from 1 to 75 per cent.; the deficiency of inorganic matter being the chief cause of difference. As this matter is shown to be of great importance to plants, it follows that the composition of soil is a subject requiring special notice.

CHEMICAL COMPOSITION OF SOILS.

233. Soils have been divided in the following way, according to the proportion of clay, sand, and lime, which they possess:—

1. Argillaceous soils, possessing little or no calcareous matter, and above 50 per cent of clay.
2. Loamy soils, containing from 20 to 50 per cent of clay.
3. Sandy soils, not more than 10 per cent. of clay.
4. Marly soils, 5 to 20 per cent. of calcareous matter.
5. Calcareous soils, more than 20 per cent. of carbonate of lime.
6. Humus soils, in which vegetable mould abounds.

Below the superficial soil there exists what is called *subsoil*, which varies in its composition, and often differs much from that on the surface. Into it the rain carries down various soluble inorganic matters, which, when brought to the surface by agricultural operations, as trenching and subsoil ploughing, may materially promote the growth of crops. The advantages of subsoil ploughing are dependent on the nature of the soil. By means of it the subsoil is loosened, so as to be easily acted upon by air and water, and the efficiency of the drainage is increased. It is not fitted for all soils, and in some instances it may do harm. A knowledge of the chemical as well as mechanical nature of soils affords to the agriculturist a certain guidance by which to direct his operations; since by the judicious application of manures, certain deficiencies may be supplied, and by the admixture of soils they may be rendered the more suitable for the purposes of vegetation.

234. **Humus,** or decaying woody fibre, exists in soils to a certain

amount. This has been called also *ulmine*, or *coal of humus*. In a soluble state it forms humic and ulmic acid. Humus absorbs ammonia, and it is slowly acted upon by the atmosphere, so as to form carbonic acid by combination with oxygen. Peaty soils contain much of this substance. When peroxide of iron is present in such soils, it loses part of its oxygen, and is converted into the protoxide.

235. **Silica** in greater or less quantity, is found in all soils; but it abounds in sandy soils. In its ordinary state it is insoluble, and it is only when acted upon by alkaline matter in the soil that it forms compounds which can be absorbed by plants. Silica, in a soluble state, exists in minute quantities in soils; the proportion, according to Johnston, varying from 0·16 to 0·84 in 100 parts, while the insoluble siliceous matter varies from 60·47 to 83·31 in 100 parts. Wiegman and Polstorf found that plants took up the silica from a soil composed entirely of quartz sand, from which everything organic and soluble had been removed. The following table shows the plants which germinated, the height to which they grew previously to being analyzed, the quantity of silica they contained when planted, and the increase :—

	Height.	Silica in the ash.		Silica had increased.
		Seed.	Plant.	
Barley	15 inches	0·034	0·355	10 times.
Oats	18 —	0·064	0·354	5½ —
Buckwheat	18 —	0·004	0·075	18 —
Vetch	10 —	0·013	0·135	10 —
Clover	3½ —	0·009	0·091	10 —
Tobacco	5 —	0·001	0·549	500 —

236. **Alumina** exists abundantly in clayey soils, but it does not enter largely into the composition of plants. It has the power of absorbing ammonia, and may prove beneficial in this way.

237. **Lime** is an essential ingredient in all fertile soils. In 1000 lbs. of such soil, there are, according to Johnston, 56 lbs. of lime; while barren soil contains only 4 lbs. The presence of phosphoric acid in soils, in the form of phosphates of potass, soda, and lime, is essential for the production of certain azotised compounds in plants; and sulphuric acid, similarly combined, is required for the formation of others. Calcareous soils contain upwards of 50 per cent of lime. The addition of lime to soils is often highly beneficial, by destroying noxious weeds and preventing disease in crops. In marly soils lime exists in the proportion of 5—20 per cent. In loamy soils lime is in smaller quantity.

238. A rough way of estimating the general nature of a soil, is thus given by Professor Johnston :—

1. Weigh a given portion of soil, heat it and dry it. The loss is water.
2. Burn what remains. The loss is chiefly vegetable matter.

3. Add muriatic acid to residue, and thus the quantity of lime may be determined.
4. Wash a fresh portion of soil to determine the quantity of insoluble siliceous sand.

Such an analysis, however, is by no means sufficient for the purposes of the farmer.

239. The chemical composition of a plant being known, conclusions can be drawn as to the soil most suitable for its growth. This is a matter of great importance both to the farmer and to the planter. In order that a plant may thrive, even in a suitable soil, exposure and altitude must also be taken into account. It is only by attention to these particulars that agricultural and foresting operations can be successful. As regards trees, the following practical observations are given as an illustration of what has been stated. The Scotch Fir thrives best in a healthy soil, incumbent on a pervious subsoil, and at a high altitude; Larch in loam, with a dry subsoil, in a high situation, and on sloping banks; Spruce and silver firs, in soft loam or peaty soil, in a low moist situation, but they will also grow in a dry soil, and in a pretty high altitude; Oak in any soil and situation under 800 feet above the level of the sea, but it thrives best in clayey loam, on a rather retentive subsoil, and on gently sloping ground; Ash and Elm, on a gravelly loam, on gravel or sand, at an altitude under 500 feet above the level of the sea; Sycamore, at 100 feet higher than the ash or elm, and in a more retentive soil and subsoil; Beech, on a dry gravelly soil, and in a rather high situation, but it is often luxuriant on strong retentive clay, and in a low damp situation.

APPLICATION OF MANURE.

240. If the soil does not contain the ingredients required for a crop, they must be added in the form of manure. The principle of manuring is to supply what the plant cannot obtain from the soil, and to render certain matters already in the soil available for nutrition. In order that this may be properly practised, there must be an analysis of the soil, of the plant, and of the manure. Hence the importance of agricultural chemistry to the farmer.

Various kinds of Manure.

241. **Natural Manures**, as farm-yard dung, are more valuable than *simple manures;* inasmuch as the former furnish all the substances required for the growth of plants, while the latter only supply a particular ingredient. Natural manures may be regarded as conferring on the soil the most lasting advantage, as from the slowness of

their decomposition their beneficial effects are not so readily exhausted. The plant itself, in a soluble state, would be the best manure. In ordinary farm-yard manure, the straw is again made available for the purpose of the plant. The whole crop of wheat and oats, however, cannot be returned to the soil, as part must be retained for food. A substitute, therefore, must be found for the portion thus taken away. This contains both azotised and unazotised matters, the former consisting of proteine compounds which supply nitrogen for the muscular tissue of man and animals; the latter of starchy, mucilaginous and saccharine matters, which furnish carbon as a material for respiration and fat. The object of manuring is chiefly to increase the former, and hence those manures are most valuable which contain soluble nitrogenous compounds.

242. The value of manures is often estimated by the quantity of gluten which is produced by their application. Hermbstaedt sowed equal quantities of the same wheat on equal plots of the same ground, and manured them with equal weights of different manures, and from 100 parts of each sample of grain produced, he obtained gluten and starch in the following proportions:—

	Gluten.		Starch.
Without manure	9·2	....	66·7
Cow dung	12·0	....	62·3
Pigeons' do.	12·2	....	63·2
Horse do.	13·7	....	61·6
Goats' do.	32·9	....	42·4
Sheep do.	32·9	....	42·8
Dried night soil	33·1	....	41·4
Dried Ox blood	34·2	....	41·3

243. Manures containing ammonia, owe their excellent qualities to the nitrogen which enters into their composition; hence the value of sulphate of ammonia, ammoniacal liquor of gas-works, and urine. The value of guano, or the dung of sea-fowl, depends chiefly on the ammoniacal salts, and the phosphates which it contains; thus supplying the nitrogen and phosphorus requisite for the proteine compounds which contain the elements of flesh and blood. The guano, which is imported, is the excrement of numerous sea-fowl which frequent the shores of South America and Africa. It often contains beautiful specimens of infusoria, as Campylodiscus, Coscinodiscus, &c. The guano found in caves on the coasts of Malacca and Cochin-China, is the produce of frugivorous and insectivorous bats, and of a species of swallow—the last being the best.

244. The following analyses by Dr. Colquhoun of Glasgow, which are the result of an examination of a large number of samples, give a general idea of the composition of guano. The term *ammoniacal matter* includes urate of ammonia and other ammoniacal salts, as

oxalate, phosphate, and muriate, as well as decayed organic matter of animal origin. The term *bone earth*, includes phosphate of lime (always the principal ingredient), phosphate of magnesia (always in small amount), oxalate of lime; and in African guano, a minute quantity of carbonate of lime, and from ½ to 2 per cent. of fragments of sea-shells. The *fixed alkaline salts*, are various salts of soda, as muriate, phosphate, and sulphate; a little of a potash salt has been detected.

South American Guano.

	Fine Chincha.	Middling.	Inferior.	Low Qualities.	
Ammoniacal matter	62	42	28	12	15
Bone earth	20	24	30	50	37
Fixed alkaline salts	10	14	21	10	5
Rock, sand, earth	0·5	5	3	15	34
Water	7·5	15	18	13	9
	100·0	100	100	100	100

African Guano.

	Best Ichaboe.	Inferior.	Low Quality.
Ammoniacal matter	45	28	20
Bone earth	20	21	17
Fixed alkaline salts	12	16	14
Rock, sand, earth	1	3	25
Water	22	32	24
	100	100	100

245. The guano from the islands on the British coasts, contains the same ingredients, but the soluble salts are generally washed out by the action of rain. The following is the analysis, by Dr. R. D. Thomson, of guano gathered on Ailsa Craig:—

Water	50·30
Organic matter and ammoniacal salts, containing 3·47 per cent. of ammonia	12·50
Phosphates of lime and magnesia	12·10
Oxalate of lime	1·50
Sulphate and phosphate of potash, and chloride of potassium	1·00
Earthy matter and sand	15·00

246. **Simple Manures** supply only one or two of the materials required for the growth and nourishment of plants. The *ammoniacal liquor of gas-works*, in a very diluted state, has been advantageously plied to the soil, on account of the nitrogen which it supplies. *Soot* also been used, from furnishing salts of ammonia. *Nitrates of* *sh and soda* have been recommended not only on account of the ies, but also on account of the nitrogen which they contain, in the

form of nitric acid. The quantity of gluten is said to be increased by the use of nitrates. *Carbonate of potash and soda* and *chloride of sodium*, are frequently used as manures. The latter is especially useful in the case of plants cultivated inland, which were originally natives of the sea-shore, as Cabbage, Asparagus, and Sea-kale. As *lime* is found in all plants, the salts containing it are of great importance. It may be used in the caustic state with the view of decomposing vegetable matter, and aiding in the formation of carbonic acid. It also neutralizes any acid previously in the soil, as is said to occur occasionally in boggy and marshy land, abounding in species of Juncus, Carex, and Eriophorum, with some Calluna vulgaris. Lime also combines with certain elements of the soil, and sets potash free, which reacts on the silica, and renders it soluble. Lime is sometimes washed down into the subsoil; and in such cases, trenching improves the land. *Phosphate of lime* is a valuable manure, both on account of the lime, and of the phosphorus which it contains. Without the presence of phosphates, gluten, and the proteine compounds of plants, cannot be formed. Phosphate of lime exists abundantly in animal tissues; and hence it must be furnished by plants. The use of bone-dust as a manure, depends in a great measure on the phosphate of lime which it contains. Besides phosphate of lime, bones contain about 3 per cent. of phosphate of magnesia, carbonate of lime, and salts of soda. The gelatine of bones also seems to act beneficially, by forming carbonic acid and ammonia. Bones are best applied mixed with sulphuric acid, so as to give rise to the formation of soluble phosphates by decomposition. They are broken into pieces, and mixed with half their weight of boiling water, and then with half their weight of sulphuric acid. The mixture is applied to the soil, either in a dry state by the drill, with saw-dust and charcoal added, or in a liquid state diluted with 100 to 200 waters. Phosphates and other inorganic matters, sometimes exist *potentially* in the soil, but in a dormant state, requiring the addition of something to render them soluble. Allowing the ground to lie fallow, and stirring and pulverizing it, are methods by which air and moisture are admitted, and time is allowed for the decomposition of the materials, which are thus rendered available for plants. *Sulphur* exists in considerable quantity in some plants, as Cruciferæ, and it forms an element in albumen; hence the use of sulphuric acid and of sulphates as manures. Sulphate of lime or gypsum, is well fitted as a manure for clover. It acts in supplying sulphur and lime, and in absorbing ammonia. *Charcoal* in a solid state, has been applied with advantage as a manure. It acts partly by taking up ammonia in large quantities, and partly in combining slowly with oxygen, so as to form carbonic acid. The effects of carbonic acid on vegetation are said to be remarkably conspicuous in some volcanic countries, in which this gas is evolved from the bottom of lakes. When it accumulates in large quantities, however, it destroys plants as well as animals.

247. **Manuring with Green Crops** is sometimes practised. The mode adopted is to sow certain green crops, the roots of which extend deeply into the soil; and when the plants have advanced considerably in growth, to plough them in, and sow a crop of some kind of grain. In this way the nutritive matter from the deeper part of the soil is brought within reach of the roots of the grain crop. Manuring with *sea-weeds* is also resorted to in cases where they are accessible. They supply abundance of carbonate, phosphate, and sulphate of lime, besides chloride of sodium. There are considerable differences in their chemical composition; thus, while in Laminaria saccharina, alkaline carbonates, potash, and iodine, predominate; in Fucus vesiculosus and serratus, sulphates and soda are in excess, and iodine is less abundant. In the cultivation of the Coco-nut Palm, Mr. M'Nab finds that sea-weeds act very beneficially.

248. **Liquid Manures** have of late years been much employed, and the formation of tanks for their reception has been strongly recommended, in which the ammonia is fixed by the addition of sulphuric acid or charcoal. They can be applied after vegetation has advanced, and they are in a state to be made at once available to the crop. More recently some have advocated a system of *steeping* seeds and grains in certain solutions before sowing them. Professor Johnston suggests a mixture of phosphate of soda, sulphate of magnesia, nitrate of potash, common salt, and sulphate of ammonia (1 lb. of each), in ten gallons of water, to steep 300 lbs. of seeds, which are to be afterwards dried with gypsum or quicklime.

249. The following experiment, conducted by Mr. Wilson, at Knock, near Largs, shows the mode of estimating the effects of manures. The land was a piece of three-year old pasture, of uniform quality. It was divided into ten lots, and these were treated with different kinds of manure. The quantity of well-made hay is given in lbs. :—

				Produce per Lot.	Rate per Acre.
Lot 1.—	Left untouched			420	3360
" 2.—	2½	barrels	Irish quicklime	602	4816
" 3.—	20	cwt.	Lime of gas-works	651	5208
" 4.—	4½	cwt.	Wood charcoal powder	665	5320
" 5.—	2	bushels	Bone-dust	693	5544
" 6.—	18	lbs.	Nitrate of potash	742	5936
" 7.—	20	lbs.	Nitrate of soda	784	6272
" 8.—	2½	bolls	Soot	819	6552
" 9.—	28	lbs.	Sulphate of ammonia	874	6776
" 10.—	100	gallons	Ammoniacal liquor of gas-works. 5° Tweddell's hdyrometer...	945	7560

The value of each application was the same, all were applied at the same time, and the grass also was cut at the same time.

250. Plants are thus employed to form from the atmosphere and soil those organic products which are requisite for the nourishment of man and animals. Nutrition derivable from the atmosphere being generally diffused, is accessible to all plants, and is perpetually renewed. Nutrition derivable from the soil being fixed to certain localities, requires that those elements contributing to it, as they become exhausted, be mechanically supplied. While an animal consumes carbon so as to form carbonic acid, gives off ammonia in various excretions, transforms organized into mineral matters, and restores its elements to air and earth; a plant, on the other hand, fixes carbon in its substance and gives off oxygen, forms from ammonia solid compounds, transforms mineral into organized matters, and derives its elements from the air and earth. Thus, says Dumas, what the atmosphere and soil yield to plants, plants yield to animals, and animals return to the air and earth, a constant round in which matter merely changes its place and form.*

EPIPHYTIC AND PARASITIC PLANTS.

251. Some plants grow without any attachment to the soil, and are able to derive in a great measure, from the atmosphere, all the materials required for their growth. Such plants are called *Epiphytes* (ἐπί, upon, and φύτον, a plant), or *air-plants*, and may be illustrated by the Tillandsias, Bromelias, and Orchids of warm climates. Such plants, when attached to the surface of trees, may perhaps derive some nourishment from the inorganic matter in the decaying bark; but they do not become incorporated, so to speak, with the trees. Orchidaceous plants, which are always perennial, are found in the greatest variety and profusion in those regions where heat and moisture abound. Extremes of cold or dryness are the least favourable to their growth. Tillandsias and Bromelias flourish in dry hot air without any contact with the earth.

252. There are other plants, however, which are true *Parasites* (παρὰ, beside, and σίτος, food, deriving food from another), sending prolongations of their tissue into other plants, and preying upon them. Many Fungi, for instance, develop their spores (seeds) and spawn (mycelium) in the interior of living or dead plants, and thus cause rapid decay. The diseases of corn, called smut and rust, and the dry rot in wood, are due to the attacks of these parasitic Fungi. The minute dust or powder produced by these plants, consists of millions of germs which are easily carried about in the atmosphere, ready to fix themselves on any plants where they can find a nidus. There are also flowering plants which

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* For fuller particulars as to the food of plants, analyses of plants, soils, manures, and rotation of crops, see Johnston's Lectures on Agricultural Chemistry; Liebig's Works; Dumas on Organic Nature; Davy's Agricultural Chemistry, by Shier; Mülder's Chemistry of Organic Bodies, translated by Fromberg; and various Papers in the Quarterly Journal of Agriculture, 1844–46; Saussure's Works; Daubeny on Rotation of Crops, Phil. Trans. 1845; Boussingault, Economie Rurale.

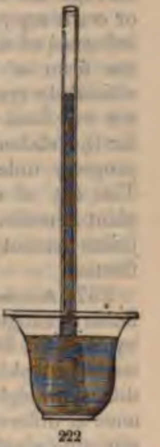
grow parasitically, and they may be divided into two classes; 1. Those which are of a pale or brownish colour, and have scales in place of leaves; and 2. Those which are of a green colour, and have leaves. The former, including Orobanche or broom-rapes, Lathræa or toothwort, Cuscuta or dodder, derive their nourishment entirely from the plant to which they are united, and seem to have little power of elaborating a peculiar sap; while the latter, as Loranthus, Viscum or mistleto, Myzodendron, Thesium, Euphrasia, Melampyrum, and Buchnera, expose the sap to the action of air and light in their leaves, and thus allow certain changes to take place in it. The Mistleto, from its power of elaboration, is able to grow on different species of plants, as on the apple, beech, oak, &c. Some of these parasites are attached to the roots of plants by means of suckers, as in the case of Broom-rapes, Toothwort, and Thesium; while others, as Dodder, Mistleto, &c., feed upon the stems. The plants to which the parasites are attached give origin frequently to their specific names. The species of Cuscuta or dodder, inhabit all the temperate and warm parts of the globe, and are peculiarly destructive to clover and lint. They are produced from seed which at first germinates in the soil like other plants; but after the stem has coiled closely round another plant, and becomes attached to it by means of suckers then all connection with the soil ceases, and the Dodder continues its life as a parasite. A remarkable tribe of parasites, called Rafflesias, has been found in Sumatra and Java. They are leafless, and produce brown-coloured flowers, which are sometimes three feet in diameter. On account of their only producing a flower and root, they are denominated *Rhizanths* (ῥίζα, a root, and ἄνθος, a flower).

2.—ABSORPTION AND CIRCULATION OF FLUIDS

253. While the leaves and other aerial organs of plants have the power of absorbing fluids, it is chiefly in the roots that this process takes place. The cells of the spongioles or fibrils of the roots, are covered by a very delicate membrane (¶ 120), which allows the imbibition of fluids to proceed rapidly; and as additions are made to their extremities, they are constantly placed in circumstances favourable for the reception of fresh nutriment. This nutriment is supplied to the plant. Animals having the power of locomotion are enabled, as they exhaust one locality of its nutrition, to remove to another. Plants being fixed, would speedily perish from want of nourishment in the surrounding soil, had not nature, while supplying by many sources the deficiencies their consumption occasions, at the same time enabled them to send roots to considerable distances in search of the requisite food. The nutritive materials in the soil, partly derived from the decomposition of organic and inorganic materials, and partly from the atmosphere,

are supplied to the roots in a state of solution; and as the substances in the cells of plants are usually denser than the external fluid matters, a process of endosmose takes place by which the latter pass through the cell-membrane in large quantities, while a small portion of the former is given off or excreted by exosmose. These movements have already been alluded to as taking place between fluids of different densities, when separated by an animal or vegetable membrane (¶ 27). They are referred by some to electrical agency, and they perform an important part in the motions of vegetable fluids.

254. Endosmose and Exosmose, then, are the names given to the phenomena of mixture through a membrane accompanied with change of volume; the former being given when the volume increases by an in-going strong current, the latter when the volume diminishes by an out-going weak current. In most cases, but not all, the dense fluid increases. The rapidity of the mixture depends on the position which the denser fluid occupies being quicker when it is uppermost. In fig. 222 is represented the mode of showing endosmose by means of a bladder full of syrup, which is attached to the end of a tube and immersed in water. In this case the water passes rapidly into the bladder by endosmose, so that the fluid rises in the tube, while a portion of the thicker fluid passes out by exosmose. The force of this endosmose may be measured by a graduated tube, as in the figure, or by a tube with a double curvature, as fig. 224, the lower part of which is filled with mercury. In the latter case, the mercury is pushed upwards into a graduated tube, and thus an endosmosmeter (μέτρον, a measure), or measure of the force of endosmose, is formed.



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255. Dutrochet found that with a membrane of 40 millimetres[*] in diameter, a tube of 2 millimetres, and a solution of sugar, the density of which was 1·083, the fluid rose 39 millimetres in the space of an hour and a-half; with syrup, of density 1·145, the rise was 68 millimetres; and with syrup, of density 1·228, the rise was 106 millimetres. Syrup of density 1·3, produced a current capable of raising a column of mercury of 127 inches, which is equal to a pressure of 4½ atmospheres. Thus the velocity and force of the rise depends on the excess of density of the interior liquor over that of the water outside. Different substances act with various intensity in producing endosmose. The following ratio expresses the variable intensity of endosmose, in different

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[*] A millimetre is about 1-25th of an English inch.

Fig. 222.—Instrument to show Endosmose and Exosmose, consisting of a bladder containing syrup attached to a tube, and plunged in a vessel of water. The inward motion of the water (endosmose) exceeds the outward movement of the syrup (exosmose).

cases in which the density of the solution was the same:—Solution of gelatine, 3; of gum, 5·17; of sugar, 11; of albumen, 12. In order that endosmose and exosmose may take place, the liquids must have an affinity for the interposed membrane, and an affinity for each other, and be miscible. According to Matteucci and Cima, the interposed membrane, whether animal or vegetable, is very actively concerned in the intensity and direction of the endosmotic current. The different surfaces of membranes also act variously, and it is probable that the physiological condition of the membrane has an important effect.

256. The fluid matters absorbed by the roots are carried upwards through the cells and vessels of the stem, under the form of *ascending* or *crude sap;* they pass into the leaves, where they are exposed to the influence of air and light, and afterwards return through the bark in the form of *descending* or *elaborated sap*, and a portion of them ultimately reaches the root, where it is either excreted or mixed with the new fluid entering from the soil. The presence of light is essential for the elaboration of the descending sap. Vegetable growth cannot progress unless the vegetable circulation be perfectly accomplished. This act of vegetable vitality may, however, be effected while the plant is removed from the action of light, but the oxygenation of the juices cannot be perfected without their free exposure to its influence.

257. **Ascending or Crude Sap.**—In order to show the course of the fluids in exogenous stems, numerous experiments have been performed by Walker, De la Baisse, Burnett, Schultz, and others. These consisted in making incisions or notches in the bark and wood of trees at different heights, and noting the points where the sap made its appearance at different periods of the year, more especially in spring; also in plunging plants with their roots entire into certain coloured solutions, and marking the course of the coloured fluids. These experiments led to the conclusion that the sap ascends chiefly through the alburnum or newer wood, proceeds along the upper side of the leaves, and returns by their lower side to the bark and root. If incisions are made into the trunk of a tree at different heights early in spring, it is found that the discharge of sap takes place, first from the lower parts of the incisions, and chiefly from the alburnum; while at a later period of the year the discharge, or the bleeding, occurs on both sides of the incision, chiefly from the new wood on the lower side, and from the bark on the upper side. If a plant be plunged into a weak solution of acetate of lead (which is capable of being absorbed), the metal may be detected, first in the new wood, next in the leaves, and then in the bark. In cellular plants, where this division of structures does not exist, the sap appears to equally permeate each cell, and to generally diffuse itself throughout the plants.

258. From the minuteness of the tissue, and the difficulty of examining the circulation in a living plant, it is not easy to determine the vessels through which the sap moves. In its upward course, it appears to pass through the intercellular spaces, the recent woody tissue and the porous vessels, and in its downward course through the laticiferous vessels and cellular tissue of the bark, being also transmitted laterally through the cells of the medullary rays. In some cases, when the bark has been removed, and the tree continues to live, the descent or fall of the sap takes place by the cells of the medullary rays. In the course of this circulation, the sap nourishes the different organs, its carbonic acid and water are partly decomposed, combinations take place with nitrogen, protoplasm or formative matter is produced, and various secretions are formed in the cells and intercellular passages.

259. Gaseous matters are taken up by the roots of plants and circulated along with the sap, as well as in the spiral vessels. These usually consist of common air, carbonic acid, and oxygen. Hales showed the existence of a large quantity of air in the vessels of the Vine, and Geiger and Proust have proved that the sap of this plant contains much carbonic acid. In some aquatic plants, as Pontederia and Trapa, there is a quantity of air contained in the vessels or intercellular spaces, with the view of floating them. In Vallisneria, the large cells in the centre of the leaves are surrounded by air cavities, which are seen as dark lines under the microscope. When cut, the air comes out in bubbles, and this escape will continue under water for several days, from the part of the leaf attached to the plant, when exposed to the light. An ounce of air has been collected from two leaves of the plant in six days. This air, as well as that contained in sea-weeds, does not enter by stomata, for none exist, but must be taken up by the cells probably in solution.

260. Changes take place in the composition and density of the sap in its upward course, but the chief alterations take place in the leaves. There it is exposed to the influence of light and air, by means of which, as will afterwards be seen, carbon and hydrogen are fixed, oxygen is given off, and an exhalation of watery fluids takes place. The sap becomes denser, and consequently the process of endosmose is promoted, so that the fluids pass from cell to cell along the upper surface of the leaf, and are gradually propelled into the lower cells, where they are acted upon by the air through the stomata, and are ultimately sent into the vascular and cellular tissue of the bark, where further changes take place. Walker, from his experiments, has concluded that until after the development of the leaves no descent takes place.*

261. **Elaborated or Descending Sap.**—The elaborated sap is sometimes clear and transparent, at other times it is milky or variously coloured and opaque. By Schultz it has been called *latex*, and the

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* Walker's Exp. on Motion of Sap in Trees. Trans. Roy. Soc. Edin. i. 3.

vessels transmitting it have been denominated *laticiferous* (¶ 38). The latex contains granules, which exhibit certain movements under the microscope. These were first noticed by Schultz, who has written a very elaborate treatise on the subject.* Carpenter considers such movements as analogous to those observable in the capillary circulation of animals. On account of these movements in the latex, the laticiferous vessels have been denominated *Cinenchymatous* (κινέω, I move), and the movements themselves are included under the name *Cyclosis* (κύκλος, a circle.) Schultz looks upon the latex as a fluid of vital importance, and similar to the blood in animals. His views are opposed by Mohl, Tristan, and Treviranus, who consider the latex as a granular fluid containing oil, resin, and caoutchouc, which exhibits molecular movements only when injury is done to the vessels containing it.

262. The plants in which the movements are best observed, are those in which the latex is milky or coloured, such as various species of Ficus, Euphorbia, and Chelidonium. In fig. 223 there is represented a small fragment of a leaf of Chelidonium majus (*celandine*), which shows the current of orange granules in the laticiferous vessels, their direction being indicated by arrows. Observation seems to confirm the truth of Schultz's statements. It is true, as Mohl remarks, that any injury done to the part examined causes peculiar oscillatory movements, which speedily cease. Thus if the young unexpanded sepal of the Celandine is removed from the plant, and put under the microscope, or if the inner lining of the young stipule of Ficus elastica be treated in a similar manner, very obvious motion is seen in the granular contents of the vessels, and this motion is affected by pricking the vessels or by pressure. In order to avoid fallacy, however, if the microscope be applied to the stipules of Ficus elastica, while still attached to the plant and uninjured, it will be remarked that, while

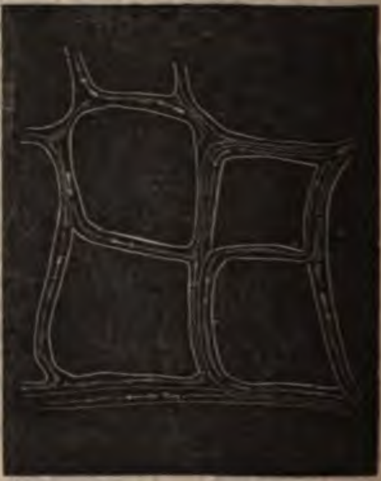

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Fig. 223.—Small portions of the leaf of Chelidonium majus or Celandine, (highly magnified), showing a net-work of laticiferous vessels. The direction of the currents in the vessels is indicated by the arrows.

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* Nova acta Academiæ Cæsar. Leopold-Carol. Naturæ Curios. tom. xviii.

pressure with any blunt object on the stipule causes a marked oscillation in the vessels showing their continuity, there will, nevertheless, be observed a regular movement from the apex towards the base, independent of external influences, when the stipule is simply allowed to lie on the field of the microscope without any pressure or injury whatever. This movement has been observed to continue for at least twenty minutes, and there is no doubt it might have been observed longer. It is of importance to distinguish between those molecular movements which are caused by injury and pressure, and those which depend on processes going on in the interior of the living plant. Those experiments, though by no means complete, lead at present to the adoption of Schultz's opinion relative to the existence of cyclosis.

263. The elaborated sap descends partly by the vessels of latex, and partly by those of the liber. It has been said that there is sometimes a difference in the sap contained in these two kinds of vessels. Occasionally, as in Euphorbia canariensis, the elaborated sap has acrid properties, while the ascending sap is bland and wholesome. The elaborated sap contributes to the formation of the cambium, which is produced between the bark and wood of exogens.

264. It appears, then, that in the case of Exogenous plants, the fluid matter in the soil, containing different substances in solution, is absorbed by the extremities of the roots, ascends to the stem, passes through the woody tissue, porous vessels and cells, dissolving and appropriating various new substances. Proceeding upwards and outwards, this sap reaches the leaves and the bark, where it is exposed to the air, and is elaborated by the function of respiration. It then returns, or descends chiefly through the bark, either directly or in a circuitous manner, communicating with the central parts by the medullary rays, depositing various secretions, more especially in the bark, and giving origin to substances which are destined to nourish and form new tissues. Finally, it reaches the extremity of the root, where absorption had commenced; a small portion is there excreted, while the remainder mixes with the newly-absorbed fluids, and again circulates in the sap. The rapidity with which the sap ascends is dependent on the endosmotic property of the cells in the roots, and on the density of the fluids. An absorption of water containing various matters in solution is constantly going on through the extremities of the rootlets. This crude sap is carried forward through the cells, vessels, and intercellular passages, by a force which acts by propulsion. The stimulus of light, acting on the cellular tissue of the leaves, enables them to elaborate the organic compounds which are necessary for vegetable nutrition. The leaf-action may be reckoned one of attraction or suction. Transpiration gives rise to a constant flow of fluids to supply the place of those exhaled.

265. In the case of Endogenous plants, observations are still wanting by which to determine the exact course of their fluids. The vascular bundles contain woody vessels, which probably are concerned in the ascent of the sap, and vessels equivalent to those of the bark and of the latex, which serve for the descent of it. The cellular tissue is also probably concerned in the movements. Cambium is produced in these plants in the neighbourhood of the vascular bundles, and is thus generally diffused through the texture of the stem. In acrogenous stems, it is likely that the sap follows the same course as in Endogens, although, in regard to both, experiments are still wanting. In cellular plants, transmission of the sap takes place from one cell to another; and, as their texture is often delicate, the movements are rapid. Many of these, as sea-weeds, when plunged into water, after having been dried by evaporation, imbibe the fluid with very great rapidity.

266. The **Cause of the Progression of the Sap** has been investigated by Malpighi, Hales, Dutrochet, Draper, Brücke, and Liebig. While the capillarity of the vessels in the higher plants operates to a certain degree, it would appear that the process of endosmose is that by which the continued imbibition and movement of fluids is chiefly carried on. From the loss of its watery contents, by exhalation, and the metamorphoses going on during the process of nutrition and secretion, the sap becomes gradually more and more dense, and thus, throughout the whole plant there is a forcible endosmotic transmission of the thinner fluids, and a constant change in the contents of the cells and vessels. These movements will of course take place with greater vigour and rapidity according to the activity of the processes going on in the leaves, which thus tend to keep up the circulation. While the ascending movement of the sap is powerfully promoted by the active operation at the surface of the leaves, its lateral movements are no less influenced by the individual relations of each distinct cell, since the different functions of separate cells when actively exercised, call into action those vital agencies by which a transmission of the cellular contents is effected.

267. Draper attributes the movement of the sap to capillary attraction, which he considers as an electrical phenomenon. This attraction takes place when a fluid moistens a capillary tube, and there can be no flow unless a portion of this fluid is removed from the upper extremity; for capillarity will not of itself raise a fluid beyond the end of the tube. Evaporation and transpiration, which take place in the leaves, remove a portion of the vegetable fluids, and thus they promote the capillary action of the vessels. When two fluids of different kinds come into contact in a tube on different sides of a membrane (which membrane being porous, may be considered as made up of numerous short capillary tubes), that will pass the fastest which wets it most completely, or has the greatest affinity for it.

Hence, Draper explains the phenomena of endosmose and exosmose by referring them to capillary attraction, aided by transpiration.

268. Liebig adopts a somewhat similar view of the phenomena. He states that the accurate experiments of Hales have shown the effects of evaporation and transpiration on the movements of sap. Transpiration takes place chiefly in clear and dry weather, and consequently is regulated by the hygrometric state of the atmosphere. When the weather is cloudy and the atmosphere moist, transpiration is checked, and stagnation of the juices takes place. The greater the transpiration, the greater the supply of fluid necessary. Hence, plants kept in the dry atmosphere of rooms fade from want of a due supply to compensate for transpiration; and hence the importance of pruning plants before transplanting them, so as to diminish the evaporating surface, and of performing the operation in dull and moist weather, so as to allow the absorption of fluids to keep pace with the transpiration. This process of transpiration, therefore, by forming a vacuum, assists capillary attraction and the atmospheric pressure, and thus the fluids rise. As the process of endosmose and exosmose depends on the chemical affinity between the fluids on each side of a membrane, the porosity of the membrane, and the attraction existing between it and either of the fluids, it follows that the nature of the parietes of the cells and vessels of plants must have a marked effect on their contents and secretions.

269. The observations of physiologists and chemists thus lead to the conclusion, that the movement of the sap in plants is due partly to the changes effected in the leaves and other green parts, by light and air; partly to capillary attraction, the continuous influence of which is kept up by the constant loss of fluids; and partly to endosmose and exosmose. It may be said that there is a *vis a tergo*, without the presence of leaves, as shown by the experiments of Hales (fig. 224), combined with *vis a fronte*, depending on the suction-power of the leaves.

270. When cut twigs or flowers are put into water, their functions are kept up for some time by endosmose and capillarity. The latter power has great influence in such a case, and hence the cleaner the cut the better, so that no lacerated or ragged edge may interrupt its operation. In these circumstances also small solid particles and colouring matters will enter the tubes. Boucherie found that felled trees, the extremities of which were immediately immersed in various solutions, continued to imbibe them with great force and rapidity for many days. A Poplar, 92 feet high, absorbed in six days nearly sixty-six gallons of a solution of pyrolignite of iron.

271. Heat and light have a powerful influence on the movements of the sap, by promoting transpiration and the action of the cells.

After the winter's repose, the first genial sunshine of spring stimulates the sap to activity, and after the leaves are expanded, the circulation goes on with vigour. The effect of leaf-buds in promoting the movement of sap, may be exhibited by introducing a single branch of a vine growing in the open air into a hot-house during winter, thus exposing it to heat and light. In this case the leaves are developed, and the fluids are set in motion from the roots upwards, so as to supply this single branch, although in the other branches there is no circulation.

272. In spring, the first effect of light and warmth is to stimulate the leaf-buds. These enlarge, and the endosmotic process commences in their cells. This is communicated to other cells, and gradually extends to the root, which draws up a continued supply of fluids from the soil. The matter stored up during the winter undergoes changes; certain substances are dissolved, and thus the sap is thickened, so that the endosmotic process is powerfully increased, and the whole plant exhibits an active and vigorous circulation. The starch deposited in the previous season becomes converted into sugar and dextrine, it is thus readily acted on by the ascending fluids, and in a state of solution admits of being generally diffused. Towards the latter part of the season, when the heat and light decrease, the leaves perform their functions more languidly, and there is a near approach to equilibrium in the density of the fluids, and ultimately there is a cessation of the circulation.

273. Liebig thinks that in the case of the vine, in which, according to Brücke, the specific gravity of the sap in spring is very little more than that of water, the rise of the sap does not at this season depend on endosmose, but on the disengagement of gas, which was shown by Hales to be given off in large quantities, when the vessels were cut. The gas is conjectured to be carbonic acid gas, judging from the experiments of Geiger and Proust, who showed that the sap of the vine contains much of this acid. There is probably also some oxygen produced in the vessels. In some stems by the breaking up of the pith cavities full of air are produced. Air-cavities are also met with in the leaves of many plants, particularly in the floating leaves of aquatics.

274. The height to which the sap rises in the case of lofty trees, with spreading roots, is very great. The force with which it ascends has been measured by Hales, and is found to vary according to the state of the weather and the vigour of the plant. By fastening a bent tube, containing mercury, on the stem of the vine, he found in one of his experiments that the sap raised the mercury upwards of thirty inches. The apparatus used by Hales is similar to that used by Dutrochet, to measure endosmose, as is represented at fig. 224, where *c* is the stem of a vine cut, *t* is a bent glass tube fitted to the

cut extremity of the vine by a copper ring, *v*, carefully luted and secured by a bit of bladder, *m; n n* represents the level of the mercury in the two branches of the lower curvature, before the experiment, and *n' n'* the level at the conclusion of it. He calculated that the force of the sap in the vine, in some of his experiments, was five times greater than that of the blood in the crural artery of the horse.

275. **Special Movements of Fluids.**—Besides this general circulation of the sap, special movements have been observed in the individual cells of plants, which have been included under the name of *Rotation* (*rota*, a wheel), or *Gyration* (*gyrus*, a circuit or circle). These motions have been detected in the cells of many aquatic plants, especially species of Chara and Vallisneria, and in the hairs of Tradescantia. The currents proceed in a more or less spiral direction, and are rendered visible by the granules of chlorophylle which they carry along with them. There exist also other granules in the fluids, which are coloured yellow by iodine, and are probably of a nitrogenous nature.

276. The species of Chara, in which rotation has been observed, are aquatic plants growing in stagnant ponds, and are composed of a series of cylindrical cells, placed end to end. Sometimes the plant consists of a single central cell; at other times there are several smaller ones surrounding it, which require to be scraped off in order to see the movements. Many of the species are incrusted with calcareous matter, so as become opaque, while others, as Chara flexilis, included

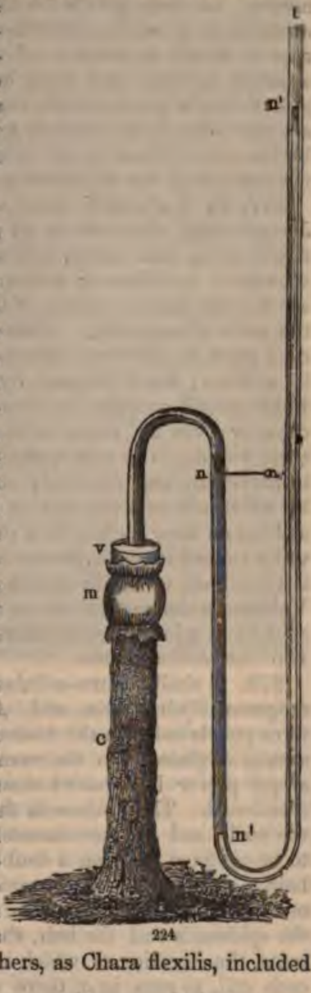

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Fig. 224.—Experiment by Hales, to show the force of ascent of the sap. *c*, Stock of a vine cut. *t*, A glass tube with a double curvature attached to the upper part of the vine-stock, by means of a copper cap, *v*, which is secured by means of a lute and piece of a bladder, *m*. *n n*, Level of the column of mercury in the two branches of the tube at the commencement of the experiment. *n' n'*, Level at the conclusion of the experiment.

under the division Nitella, have no incrustation, and are transparent. Those plants with unincrusted tubular cells best exhibit such movements. In these plants the movements take place between the two membranes of which the cell-wall is composed. They are not interrupted should a division of the cell be effected by ligature, as a separate motion may then be observed in either section. Some granules, of a green colour, are attached to the cell-wall, while others are carried with the current, which passes along one side and returns by the other, following an elongated spiral direction. The descending current in the branches is next to the axis.

277. In Vallisneria spiralis (which includes V. Micheliana and Jacquiniana), the cells in all parts of the plant, as in the leaf, root, flower-stalk, and calyx, contain numerous green granules, and an occasional cytoblast or nucleus, which, under certain circumstances, are carried, with the juices of the plant, in continual revolution round the walls of each cell. Although in different cells the currents proceed often in different directions, still, in any given cell the rotation is uniform; for if stopped by cold it resumes the same direction. Rotation will continue in detached portions of the plant for several days, or even for three or four weeks. The best way of showing these motions is to take a small portion of a young leaf and divide it in halves, by making a very oblique section on the plane of the leaf, by which means a transparent end is obtained. This should be done at least an hour before it is put under the microscope. The part is to be viewed in water, between two pieces of glass; and a little heat is sometimes useful in causing the movements to commence. In Vallisneria the motion ceases at about 45° Fahr., while in Chara, it goes on at a lower temperature; if the temperature be raised above 150° the motion ceases.

278. A similar intra-cellular circulation is seen in species of Potamogeton, Hydrocharis, and Anacharis, as well as in the moniliform purple hairs on the filaments, and in the calycine hairs of Tradescantia virginica. In the examination of these hairs a higher microscopic power is required than in the case of the plants previously mentioned. The nucleus in the cells of these hairs is usually fixed to the walls, and the movements take place to and from it, and appear to be confined between a double cell-wall. Fig. 225 shows a calycine hair, *p*, of Tradescantia virginica, with a small portion of the epidermis, *e e*, on which a stoma, *s*, is seen. In each of the cells, both of the epidermis and the hair, there is a nucleus, *n*, and rotatory currents, the direction of which is indicated by that of the arrows. In each cell, as seen in *a*, there are several currents, which cross each other at the point where the nucleus is situated, thus giving rise to the appearance of an irregular net-work. The hairs of many other

flowering plants exhibit rotation (fig. 86), and it is probable that in all young cells there are currents or streams radiating from the nucleus. The fluid circulating is a mucilaginous protoplasm or formative matter, and in Chara and Vallisneria it forms a uniform investing layer on the inner surface of the cell. The motions would appear to be connected in some way with the nutrition of cells and the formation of new ones; and, while they continue throughout life in aquatics, they often cease in plants living in air, after they have attained a certain development. Mohl's experiments have shown that at the temperature of 66° Fahrenheit, the quickest motion was 1-125th of a Parisian line,* the slowest, 1-600th, and the mean, 1-185th.

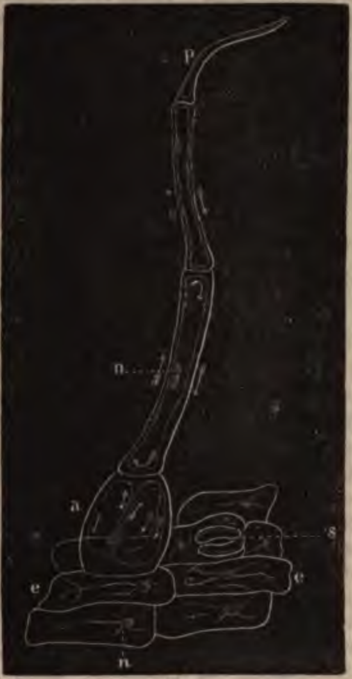

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Fig. 225.—Hair, *p*, taken from the calyx of Tradescantia virginica, with a small portion of the epidermis, *e e*, on which there is a stoma, *s*. In each of the epidermal cells there is a nucleus, *n*, and currents (rotation), the direction of which is indicated by the arrows. In each cell there are several currents moving to and from the nucleus, as is well seen at *a*. In the elongated cells of the hair, the nucleus, *n*, is carried along with the currents

279. Some of these movements, especially in hairs, were looked upon by Schultz as occurring in minute vessels, and therefore he included them under cyclosis. Schleiden maintains that in the Vallisneria cells it is not the cellular sap that is in motion, but a mucilaginous fluid, with which the chlorophylle granules and the nucleus are connected, and which flows in an uninterrupted manner along the cell-walls, but on account of its transparency and slight thickness, is not easily seen. In Chara, also, he states it is not the cell-sap which moves, but a denser fluid, present in large quantity, and occupying the outer part of the cell-cavity. Mohl thinks that a homogeneous protoplasm fills these cells at first completely, but that during growth it becomes hollowed out into one or more cavities, and that around these the mucilaginous matter circulates. In Vallisneria, there is only one cavity, while in other plants there are several, giving rise to the

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* Parisian line = 088815 of inch.

appearance of mucilaginous streams or lines running from the nucleus to the cell-wall. These mucilaginous lines, he says, occasionally after the circulation has ceased, remain permanently on the cell-wall. The existence of spiral fibres in cells has been traced to currents of this kind. Amici is of opinion that in chara the chlorophylle-granules lining the walls of the cell exercise a galvanic action upon the sap, and that the action is thereby produced.

280. The velocity of the currents in various plants, at 66° to 68° Fahrenheit, is thus given by Mohl:—

Filamental hairs of Tradescantia virginica,—$\frac{1}{300}$ to $\frac{1}{900}$ of a Parisian line in a second; mean, $\frac{1}{500}$.
Leaves of Vallisneria spiralis—quickest, $\frac{1}{125}$; slowest, $\frac{1}{800}$; mean, $\frac{1}{187}$ of a line in a second.
Stinging hairs of Utrica baccifera—quickest, $\frac{1}{327}$; slowest, $\frac{1}{875}$; mean, $\frac{1}{750}$.
Cellular tissue of young shoot of Sagittaria sagittifolia, $\frac{1}{758}$, to $\frac{1}{1058}$; mean, $\frac{1}{854}$.
" " leaf of do., $\frac{1}{1170}$, to $\frac{1}{1360}$; mean, $\frac{1}{1255}$.
Hairs of Cucurbita Pepo—quickest, $\frac{1}{770}$; slowest, $\frac{1}{3760}$; mean, $\frac{1}{1847}$.

The measurements were made by noting the passage of the globules across the field of a micrometer, fixed in the ocular of the microscope, and counting the strokes of a second's pendulum. These movements appear more rapid to the observer; but then it must be recollected that the parts are seen in a highly magnified state.

281. **The Cause of Rotation** has not been satisfactorily explained. Some attribute it to electrical or magnetic currents causing attraction and repulsion of the granular contents of cells. The different contents of the cells, according to them, mutually act and react on each other, and thus give rise to movements similar to those which take place on the surface of water when oily or resinous matters are added, and which have been called *epipolic* (ἐπιπολῆς, on the surface). Recent observations, by Dutrochet, seem to show that the magnetic force exercises no influence over the movements in Chara. Others believe that while heat, and electricity, and physical agents, stimulate these movements, they are not the cause of them. Some trace the movements to the presence of the nucleus, and look upon them as connected with the period of growth when new cells are being formed, and as ceasing after the nucleus has disappeared. Mechanical explanations fail to explain the nature of those movements. This rotation or gyration is not connected with general circulation of the sap, but is a special movement in individual cells. As yet, no good explanation of it has been brought forward. All we can say is, that the motions must be considered as physico-vital phenomena.

3.—RESPIRATION OF PLANTS.

282. The changes which are produced in the atmosphere by living plants have been included under the title of *Vegetable Respiration*. The experiments of Priestley, in 1771, showed that plants when put

into an atmosphere containing a considerable proportion of carbonic acid, and exposed to light, purified the air by removing carbon and producing oxygen. Air in which animals had died was thus rendered again fit for breathing. Percival confirmed those observations. Scheele made a series of experiments with nitrogen in place of carbonic acid, and he found that plants did not purify an atmosphere composed of nitrogen alone. The *foul* air, then, in his experiments, differed completely from that in Priestley's experiments, and hence the difference of results. Ingenhouz and Senebier performed numerous experiments, which proved that during the day, plants gave out oxygen gas, while during darkness, this process was suspended. The former has shown that the green portions of all vegetables, irrespective of their specific properties, are equally available for such operations; that it is from the under surface of the matured leaves that oxygen is chiefly given off; and that in plants placed in the shade the action of the leaves does not prevent deterioration of the air. Saussure stated, that during the night, oxygen gas was absorbed in different quantities by plants. Fleshy plants absorbed least; next came evergreen trees, and then deciduous trees and shrubs. This absorption of oxygen is attended with the formation of carbonic and other acids. It has been said that some leaves, on account of this process of oxidation, are acid in the morning, and become tasteless during the day. Decandolle, Ellis, Daubeny, and numerous other observers, have confirmed the conclusions drawn by the early experimenters. The results of all these observations are, that plants, more especially their leaves and green parts, have the power of decomposing carbonic acid under the influence of solar light, and of evolving oxygen. While in darkness, no such decomposition takes place, oxygen is absorbed in moderate quantity, and some carbonic acid is given off. The former process caused by the deoxidizing power of plants, much exceeds the latter in amount.

283. Burnett endeavoured to show that there are two processes constantly going on in plants, one being what he calls *digestion*, consisting in the fixation of carbon and the evolution of oxygen, and only carried on during the day; the other being what he calls *proper respiration*, consisting in the evolution of carbonic acid gas, and carried on at all periods of a plant's growth. He thinks that his experiments prove the disengagement of carbonic acid from the leaves of plants, both during night and day. Carpenter entertains similar opinions. He considers that under all circumstances vegetable respiration is a process continued throughout and essential for vegetable life, that it consists of the elimination from the system of the superfluous carbon, either by its entering into combination with the oxygen of the air, or by giving off carbonic acid to replace the oxygen absorbed.*

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* Carpenter, Prin. Phy. p. 730.

Mr. Pepys is of opinion that the evolution of carbonic acid indicates an abnormal condition of the leaf, which, in the process of healthy active vegetation, absorbs carbonic acid and disengages oxygen. He believes that the action of light leads to the greater perfection of this function which is less energetically performed, if not wholly suspended during the night.* What is generally called vegetable respiration, may be regarded as equivalent to digestion, consisting, as it does, of the decomposition of certain matters, and the fixation of others by a process of assimilation; but there is no evidence of the constant exhalation of carbonic acid from healthy leaves in the same way as occurs in animal respiration. It would appear to be more correct to consider the processes in animals and vegetables as opposed; respiration in the former being the elimination of carbon, while in the latter it is the elimination of oxygen.

284. The changes produced in the atmosphere are caused chiefly by the superficial green parts of plants. It was long ago supposed that the spiral vessels from their structure were to be looked upon as true wind-pipes or tracheæ, conveying air from the stomata or pores in the leaves. But although they contain aeriform matters, they have been shown to be not directly concerned with the changes in the atmosphere, and to have no immediate connection with the stomata. The oxygen evolved by plants appears to be derived from the carbonic acid (CO^2), the carbon of which is appropriated, and from water (HO), the hydrogen of which is assimilated. Light is necessary for these decompositions, and it is probable that the alkalies taken up by the roots aid the process.

285. If the leaves of a plant are bent under an inverted tumbler of water, in a pneumatic trough, and exposed to the sun, bubbles of gas will soon be given off, which are found to be pure oxygen; and if the water contains carbonic acid, there will be a diminution in its quantity. The same leaves in darkness will not evolve any oxygen, light being essential for the process. The oxygen derived from the carbonic acid may be all evolved, or part of it may in its nascent state enter into certain combinations within the plant. The brighter and longer continued the light, the more oxygen is given off, and the greater the quantity of carbon added to the plant. If a healthy plant is covered by a bell jar, and exposed to light for twelve hours, oxygen will be formed, and if carbonic acid be added to the air, it will gradually diminish, while the oxygen will increase. During the night the action is reversed, and if the plant is left twelve hours in darkness, the oxygen will decrease, while carbonic acid will increase. Daubeny, from his experiments respecting the action of plants on a known amount of atmospheric air—effected by placing plants beneath large glasses,—

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* Pepys on the Respiration of Leaves of Plants. Phil. Trans. 1843, p. 329.

states that leaves are requisite for the purification of the air, that the action of light on them gives rise to the emission of oxygen, and the decomposition of carbonic acid, that for the elimination of oxygen the presence of carbonic acid is requisite, and that the greatest amount of oxygen which can, by vegetable respiration, be added to air confined within a jar is 18 per cent.*

286. The fixation of carbon probably takes place gradually, giving rise at different stages to the formation of various organized compounds. Thus, two atoms of carbonic acid, by losing one of oxygen, become oxalic acid; this oxalic acid, with the aid of water, may yield other acids, from which by the elimination of oxygen, and the addition of the elements of water, various unazotised matters, as starch, gum, and sugar, may be derived; these changes being promoted by the presence of alkalies. The fixation of carbon and hydrogen from the decomposition of carbonic acid and water, gives rise to the formation of the various secretions found in the bark and external cells, as chlorophylle, resins, oils, caoutchouc, and wax.

287. Carbonic acid, as has been already noticed, is taken up in large quantity by the roots of plants from the soil, and it is also probably absorbed from the atmosphere by the leaves. In the interior of plants it is changed in various ways, but it is in the leaves more especially that its decomposition takes place. At night it is given off unchanged, by what Liebig considers as a mere process of exosmose, in consequence of the dissolved acid being no longer assimilated by the action of light. Others say that carbonic acid is not produced by exhalation only, but is also derived from the direct union between the oxygen of the air and the carbon of the plant. This may occur in some plants without leaves, as Fungi, where a direct process of oxidation takes place in the organic matters which have been assimilated. The quantity of this acid given off during the night, is by no means equal to that which is absorbed by the plant during the day.

288. The parts of plants which are not green, seem to absorb oxygen. Thus, roots and subterranean organs act in this way, and the presence of oxygen seems to be necessary for their growth. There are also certain periods in the life of a plant when carbonic acid is given off in large quantity, even during the day, depending on a chemical change taking place in the starch of the plant, by which it is converted into sugar. These periods are germination, flowering, and fruiting. The changes produced will be alluded to when these subjects are considered. When plants are decaying, or are in an unhealthy state, they undergo chemical changes, by which carbonic acid is formed. This was found by Burnett to have influenced the results of some of Mr. Ellis's early experiments.

289. Certain plants have a great power of decomposing carbonic

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* Daubeny on the Action of Plants on Atmosphere. Phil. Trans. 1836, p. 163.

acid under the action of light. This is particularly the case with aquatics. It is thus that they keep up the purity of the pools and ponds in which they grow. Pistia Stratiotes has this effect in the Batavian ponds, and Sir H. Davy notices the great vigour of aquatic plants in the lake Solfatara, where carbonic acid was constantly bubbling up on the surface. The oxygenation of the water by aquatics has also been observed by Morren of Geneva.

290. Experiments have been made as to the effect of the different rays of the spectrum in aiding the decomposition of carbonic acid, by the green parts of plants. Draper states that the light-giving rays, or those nearest the yellow, have the greatest effect; while the heat-giving and the tithonic, or chemical rays, had scarcely any influence. The experiments of Hunt also lead to the conclusion, that the yellow rays have most effect in the fixation of carbon, and in the production of woody matter.

291. While the breathing of man and animals, and the various processes of combustion, are constantly abstracting oxygen from the atmosphere, and substituting carbonic acid, plants are decomposing this noxious gas, and restoring the oxygen. In tropical countries, where the vegetation is luxuriant and the light intense, the fixation of carbon and evolution of oxygen goes on with great vigour, thus furnishing a supply to those regions where, during certain periods of the year, both vegetation and heat are deficient.

Effects of certain Gases on living Plants.

292. It has been already stated that plants can live in an atmosphere containing a considerable proportion of carbonic acid, provided they are exposed to the light. Thus, an atmosphere which could not be breathed by man and animals is capable of supporting vegetable life. The experiments of Priestley, Percival, and Saussure, show, however, that plants will not continue to exercise their functions in pure carbonic acid gas, but that in all cases a certain quantity of free oxygen must be present. It has been found that though plants do not *thrive* in pure nitrogen, nor in hydrogen gas, yet their vitality is not destroyed by their presence. Saussure observed that vegetable life was maintained by a plant of Lythrum Salicaria for five weeks, in an atmosphere of hydrogen gas. Nitrogen has been proved to be apparently innocuous. These gases seem of themselves to have no directly injurious effects, but to act chiefly by depriving the plants of carbon and oxygen.

293. There are certain gases which have very prejudicial effects on plants, as proved by the experiments of Turner and Christison.*

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* See Edinburgh Medical and Surgical Journal. vol. xxviii. p. 356.

Some of them act as irritant poisons, causing local disorganization; others as narcotic poisons, inducing a drooping and decay of the entire plant. To the former class belong sulphurous acid gas, hydrochloric or muriatic acid gas, chlorine and nitrous acid gas; while under the latter are classed sulphuretted hydrogen, cyanogen, carbonic oxide, and ammoniacal gas.

294. **Sulphurous Acid Gas** is highly injurious to plants. It produces greyish-yellow dry-looking spots on the leaves, which gradually extend until the leaves are destroyed and fall. The effect resembles much the ordinary decay of the leaves in autumn. The proportion of gas, in some experiments, was only 1 in 9,000 or 10,000 parts of air, and the quantity $\frac{1}{3}$ of a cubic inch; and yet the whole unfolded leaves of a mignonette plant were destroyed in forty-eight hours. This proportion of the gas is hardly or not at all discoverable by the smell.

295. **Muriatic Acid Gas** produced effects similar and scarcely inferior to those of the last-mentioned gas. When $\frac{1}{3}$ of an inch was diluted with 10,000 parts of air, it acted destructively on Laburnum and Larch, destroying the whole vegetation in less than two days. Even when in quantity not perceptible by the smell, it still acts as an irritant poison.

296. **Sulphuretted Hydrogen** acted in a different way from the acid gases. The latter attacked the leaves at the tips first, and gradually extended their operation to the leaf-stalks. When in considerable proportion, their effects began in a few minutes; and, if diluted, the parts not attacked generally survived if the plants were removed into the air. But in the case of sulphuretted hydrogen, the leaves, without being injured in texture or colour, became flaccid and drooping, and the plant did not recover when removed into the air. It required a larger quantity of this gas to produce the effects stated. When six inches were added to sixty times their volume of air, the drooping began in ten hours. This gas then acts like a narcotic poison, by destroying vegetable life throughout the whole plant at once.

297. These observations point out the great injury which is caused to plants by the gases given off during the combustion of coal, and more especially by certain chemical works. In the vicinity of the latter, the vegetation, for a considerable distance around, is often destroyed, particularly in the direction of the prevailing winds of the locality. The atmosphere of large manufacturing towns, in which fuliginous matter and sulphurous gases abound, is peculiarly hurtful to vegetable life. In order to protect plants from such prejudicial influences, Mr. N. B. Ward has invented close glass Cases, in which plants can be made to grow independently of the noxious atmosphere around.* These Cases consist of a trough containing soil, and a frame of glass, which is accurately fitted upon it. The soil is well supplied

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* See Ward on the growth of plants in closed Cases.

with water at first, and after the plants are put in they are kept exposed to the light. In these circumstances, they will continue to thrive for a long time, even for years, without any fresh supply of moisture or any direct exposure to the air. They are peculiarly fitted for rooms where the dryness of the atmosphere interferes with the vigour of plants, by causing greater exhalation than can be compensated by the absorption of moisture by the roots. Some tribes of plants, as Ferns, requiring a humid atmosphere, thrive well in such Cases. The windows of houses may be converted by this means into conservatories. Those who wish to see the effects thus produced, ought to visit Mr. Ward's house, at Clapham Rise, London. Nothing can exceed the beauty and luxuriance of his Ferns.

298. But it is not merely as matters of luxury and curiosity that these Cases deserve notice. They serve as a most important means of transporting plants, in a living state, to and from foreign climates; and they are in constant use for that purpose. Plants have thus been brought to this country which could not have retained their vitality in the form of seed, and which would have been destroyed by exposure to the sea-breeze and to the vicissitudes of climate experienced during their transport. Plants of Musa Cavendishii have thus been introduced into the South Sea Islands with the happiest results; Tea plants have been transported in great numbers from China to India. Mr. Fortune sent to the London Horticultural Society a number of these Cases filled with plants from China. The stillness of the atmosphere in the Case contributes materially to prevent injurious consequences. In June 1833, Mr. Ward filled two Cases with Ferns, Grasses, etc., and sent them to Sydney, where they arrived in January 1834. The plants were taken out in good condition, and the Cases were refilled at Sydney, in February 1834, the thermometer then being between 90° and 100° Fahrenheit. In their passage to England, they encountered very varying temperatures. The thermometer fell to 20° on rounding Cape Horn, and the decks were covered a foot with snow. In crossing the line, the thermometer rose to 120°, and fell to 40° on their arrival in the British channel in the beginning of November, eight months after they had been enclosed. The plants were not once watered during the voyage, and received no protection by day or by night, but were taken out at Loddiges in a most healthy and vigorous condition.

299. It is a mistake to suppose that the air in the Cases is not changed. They are not hermetically sealed; and by the law of diffusion of gases there is a constant although gradual mixture of the external air, free however from many impurities, with that inside. Plants will continue to grow for a long time, even in Cases hermetically sealed, if supplied at first with abundance of good soil and water. By the united action of the plant and light, the air undergoes constant changes, and thus continues fit for vegetable life.

4.—PRODUCTS AND SECRETIONS OF PLANTS.

300. The sap in its progress through the cells and vessels, and especially in its passage through the leaves, is converted into organizable products, from which the vegetable tissues and the secretions contained in them are elaborated. Light, by enabling plants to fix carbon, has an important influence over these secretions. When plants are kept in darkness they become etiolated or blanched, and do not form their proper secretions. Gardeners resort to the practice of blanching when they wish to diminish or destroy certain secretions, and to render plants fit for food; a familiar example of which may be seen in their culture of the Apium graveolens or Celery. In speaking of the contents of cells and vessels, allusion has already been made to some of the more important organizable products. It is proposed in this place to take a general view of those vegetable secretions which are connected with the nutrition of plants, or which are important on account of their medical or commercial uses. Some of these occur in small quantity, and are limited to certain plants only; others are abundant, and more universal in their distribution. Thus, while quinine and morphine, the active ingredients of Peruvian bark and opium, are circumscribed, both as regards quantity and distribution, starch, gum, sugar, woody matter, and certain nitrogenous compounds are more abundant, and more generally diffused over the vegetable kingdom. The latter substances therefore demand especial attention. If a plant is macerated in water, and all its soluble parts removed, lignine or woody fibre is left, and the water in which it has been macerated, gradually deposits starch. If the liquid is boiled, a scum coagulates, formed of albumen and some azotised matters, while gum and sugar remain in solution.

301. **Starch** is a general product, being laid up as a store of nourishment, and undergoing changes at certain periods of a plant's life, which fit it for further uses in the economy of vegetation. It is not found in animal cells. It consists of $C^{12} H^{10} O^{10}$, and occurs in the form of grains of various sizes and forms, having an external membrane, enclosing a soluble substance. By boiling in water, the pellicle bursts, and the contents are dissolved, becoming gelatinous on cooling. The circular markings and striæ seen on the grains, and the part called the hilum, have already been noticed (¶ 17). The grains of potato starch seen by polarized light, exhibit a well-marked black cross, the centre of which corresponds with the hilum. Some plants, such as potato, arrow-root, and wheat, contain a large quantity of starch, which varies, however, in quantity according to the period of growth. Thus, while starch abounds towards the latter part of the season in the potato, it decreases when the tubers begin to germinate in spring.

It was found that 240 lbs. of potatoes, left in the ground, contained of starch :—

In August..........	23	to 25	lbs., or	9·6	to 10·4	per cent.
" September.......	32	" 38	" "	13·3	" 16	"
" October..........	32	" 40	" "	13·3	" 16·6	"
" November.......	38	" 45	" "	16	" 18·7	"
" April.............	38	" 28	" "	16	" 11·6	"
" May...............	28	" 20	" "	11·6	" 8·3	"

The quantity of starch remained the same during the dormant state in winter, but decreased whenever the plant began to grow, and to require a supply of nourishment.

302. Starch is stored up in many seeds. It exists in roots, especially in those which are fleshy; in stems; in the receptacles of flowers; and in pulpy fruits. The seed-lobes of the Bean and Pea, and many other leguminous plants; the roots and the under-ground stem of Maranta arundinacea or Arrow-root, and of Canna coccinea or Tous-les-mois, Canna Achiras and C. edulis; the stem of the Sago Palm (Sagus Rumphii and farinifera), and of the Cycas tribe; the receptacle of the artichoke, and the pulp of the apple, are familiar instances of parts in which starch abounds. The grains of potato-starch are pearly or sparkling in their appearance, of large size, having one or more hila, and often cracks on the surface Those of arrow-root are dull, white, and small, while those of Tous-les-mois, present a glistening appearance like potato-starch, and are larger. In some cases, starch is associated with poisonous or acrid juices, as in Jatropha Manihot, which yields Cassava and Tapioca, and in Arum maculatum, the under-ground stem of which furnishes Portland sago. Inuline is a substance analogous to starch, to which Iodine communicates a brown colour. It is found in the roots and tubers of Inula Helenium (Elecampane), Dahlia variabilis, and Helianthus tuberosus (Jerusalem artichoke); while Lichenin is a variety of starch occurring in Cetraria islandica (Iceland moss). Lichenin or lichen starch consists of $C^{12} H^{10} O^{10}$, and is deposited in the primary cell-wall of the plant, in the form of an encrusting layer. By the action of malt or of sulphuric acid upon starch, by long boiling in water, or by heating in a tray in an oven whose temperature has been raised to 300° Fahrenheit, a gummy matter is produced called *dextrin*,* or soluble starch composed of $C^{12} H^{10} O^{10}$. Some consider this to be the substance contained in the interior of the starch grains. When dried, it constitutes British gum. It is one of the steps in the process of the conversion of starch into sugar.

303. **Gum** is one of the substances which are produced abundantly in the vegetable kingdom. Its composition is $C^{12} H^{11} O^{11}$, the same as that of Cane-sugar. It exists in many seeds, exudes from the stems

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* Dextrin is so called from possessing the property of effecting the right-handed rotation of the *plane of polarization* of a ray of light.

and twigs of many trees, and is contained in the juices of others from which it does not exude. It is one of the forms through which organic matter passes during the growth of plants. The different kinds of gums have been divided into those which are soluble in cold water (Arabine, mucilage), and those which only swell up into a gelatinous matter (Bassorine or Tragacanth, Cerasine and Pectine). Arabine is familiarly known by the name of gum-arabic or gum-senegal, and is the produce of various species of Acacia, chiefly natives of Arabia, Egypt, Nubia, and Senegambia, such as Acacia Ehrenbergii, tortolis, Seyal, arabica, vera, and albida. From the bark of these plants it exudes in the form of a thick juice, which afterwards concretes into *tears*. Ehrenberg has shown that the characters of gum from the same species of plant are liable to considerable variation; that the same tree may yield a transparent or an opaque, a light or a dark coloured gum. Old stunted trees, in hot and dry seasons, yield the most gum. Arabine exists with cerasine in the gum of the Cherry and Plum. *Mucilage* is present in many of the Mallow tribe, as Malva sylvestris, Althæa officinalis or marsh mallow, and in Linseed. In Sphærococcus crispus, mucilage is present, of which the formula is $C^{24}\ H^{19}\ O^{19}$. *Bassorine* forms the chief part of gum-tragacanth, the produce of several species of Astragalus, and of gum-bassora. It exists in Salep, procured from the tubercules of Orchis mascula. *Cerasine* is that part of the gum of the Cherry (*Cerasus*), Plum, and Almond trees, which is insoluble in cold water. *Pectine* is a substance procured from pulpy fruits, as the apple and pear. It forms a jelly with water, and when dried, resembles gum or isinglass. It is changed by alkalies into pectic acid, which is found in many fruits and esculent roots.

304. **Sugar.**—This substance, which forms an important article of diet, exists in many species of plants. Sugars have been divided into those which undergo vinous fermentation, as Cane and Grape sugar, and those which are not fermentescible, as Mannite. *Cane sugar*, $C^{12}\ H^{9}\ O^{9} + 2\ HO$, is procured from Saccharum officinarum (sugar-cane), Beta vulgaris (beet-root), Acer saccharinum (sugar-maple), and many other plants. It has been conjectured that the Calamus or sweet cane mentioned in the Old Testament, may be the sugar cane. At all events, the plant was known as early as the commencement of the Christian era. In the East and West Indies, at the present time, numerous varieties of cane are cultivated, such as Country cane, Ribbon cane, Bourbon cane, Violet or Batavian cane, which are distinguished by their size, form, the position and colour of their joints, their foliage, and their glumes. Bourbon cane is richest in saccharine matter. Canes demand a fertile soil, and for their perfect maturation they require from twelve to fourteen months. Those which are grown from planted slips, are *plant-canes*, those which sprout up from the old stems, are *rattoons*. After being cut, the canes are crushed (the pressed canes

being called *begass*), the saccharine juice is extracted, evaporated, and crystallized, as Raw or Muscovado sugar, which is afterwards refined in vacuo, so as to form *loaf* sugar.

305. In 1844, the gross amount of sugar entered for consumption in the United Kingdom was 4,139,994 cwt. The quantity of sugar produced from the sugar cane in different parts of the world, in 1839, has been thus estimated:—

British Sugar Colonies	3,571,378 cwt.
British India	519,126 —
Danish West Indies	450,000 —
Dutch West Indies	260,000 —
French Sugar Colonies	2,160,000 —
United States of America	900,000 —
Brazil	2,400,000 —
Java	4,481,342 —

306. *Maple Sugar* is much used in America. It is procured from the sugar maple by making perforations in the stem, and allowing the sweet sap to flow out. Two or three holes, at the height of eighteen or twenty inches from the ground, are said to be sufficient for an ordinary tree. The season of collecting is from the beginning of February to the middle of April. *Beet sugar* is the produce of the root of Beta vulgaris, and is extensively manufactured in many parts of the continent. In the year 1841, there were 142,518 acres in France planted with beet-root for sugar, and the quantity of sugar produced was 31,621,923 kilogrammes (one kilogramme being equal to about 2½ lbs). In Ireland much attention has been directed to the culture of this root with the view of manufacturing sugar. A public company has been formed to carry out the undertaking. Though the sugar obtained has been of a superior quality, it does not appear to have been hitherto afforded in sufficient quantity to render its manufacture profitable as a speculation. *Manna sugar*, or *Mannite*, differs from the others in not being fermentescible. Its composition is $C^6 H^7 O^6$. It is the chief ingredient of Manna, which exudes from the Ornus europæa and rotundifolia. From Sicily and Calabria it is exported under the name of flake-manna. Mannite is found in the juices of Mushroom, in Celery, and in Laminaria saccharina, and Eucalyptus mannifera. Dr. Stenhouse has determined the quantity of Mannite in some sea-weeds as follows:—

Laminaria saccharina	12 to 15 per cent.	of Mannite.
Halydris siliquosa	5 to 6 per cent.	—
Laminaria digitata	4 to 5 per cent.	—
Fucus serratus	rather less.	—
Alaria esculenta	about the same.	—
Rhodymenia palmata	2 to 3 per cent.	—
Fucus vesiculosus	1 to 2 per cent.	—
Fucus nodosus	nearly same.	—

Knop and Schnederman have detected Mannite in Agaricus piperatus, and other chemists have found it in Cantharellus esculentus, and Clavellaria coralloides.

307. *Grape sugar*, called also Starch sugar, or Glucose, is composed of $C^{12} H^{14} O^{14}$. It occurs in the juices of many plants, and is a product of the metamorphoses of starch, cane sugar, and woody fibre. It may be extracted from dry grapes, and may be prepared from starch by the action of an infusion of malt, or of a substance called Diastase (¶ 310). It is less soluble and less sweet than cane-sugar. It gives sweetness to gooseberries, currants, apples, pears, plums, apricots, and most other fruits. It is also the sweet substance of the chestnut, of the brewer's wort, and of all fermented liquors.

308. **Lignine** is the substance which gives hardness and solidity to the cells and vessels of plants. It exists abundantly in woody fibre, which may be said to be composed of cellulose forming the parietes, and lignine forming the encrusting matter in the interior, or the Sclerogen of Payen. The latter dissolves in strong nitric acid, forming oxalic acid, while the former is left undissolved. Lignine is said to be composed of $C^{35} H^{24} O^{20}$. According to Mülder, the formula for the ligneous matter of ordinary wood is $C^{40} H^{28} O^{26}$. When a portion of the stem of a herbaceous plant, or of newly cut wood, is reduced to small pieces and boiled in successive portions of water, alcohol, ether, diluted acids and alkalies, until everything soluble in these menstrua is removed, a white fibrous mass remains, to which the name of woody fibre is given. It varies slightly in its composition in different trees, thus:—

	Oak.	Beech.	Pine.	Willow.
Carbon	52·53	51·45	50·	49·8
Hydrogen	5·69	5·82	5·55	5·58
Oxygen	41·78	42·73	44·45	44·62

Iron wood contains 53·44 per cent. of carbon.

This woody fibre exists in linen and paper; and these substances, when subjected to the action of sulphuric acid, are converted into grape sugar. Lignine gives support to the vegetable texture, and is often deposited in concentric layers. It occurs in large quantity in the wood of trees, and is also present in the stem of herbaceous plants. In some cellular plants it is absent, and the object of many horticultural operations, as blanching, is to prevent its formation. Beet-root and white turnips contain only 3 per cent. Lignine is not coloured by iodine.

309. All these organic substances, consisting of carbon united with the elements of water, are easily convertible into each other by the action of sulphuric acid and heat. Similar changes are induced during

the growth and development of plants, as will be noticed under the head of flowering, fruiting, and germination. In many unazotised matters the proportion of the elements is the same, or they are *isomeric*. Thus, cellulose and starch have the same composition, and the difference in their qualities seems to depend on the mode in which the elements are united. Their form is altered by a change in the molecular arrangement. The unazotised products which have been noticed, supply carbon for the respiration of man and animals, and probably assist in the formation of fat. It is impossible to notice all the compounds of carbon, oxygen, and hydrogen, found in plants. For example, Salicine, a bitter neutral crystalline substance, is procured from the bark of Salix alba, Helix, purpurea, viminalis, pentandra, &c.; and Phloridzine, an analogous substance, occurs in the bark of the roots of the apple, pear, and plum.

310. **Azotised Products.**—There are certain azotised products which exist in greater or less quantity in plants, and which are particularly abundant in grains and seeds. The nutritive matter of wheat consists of starch or unazotised matter, separable by washing, and of azotised matter or gluten. *Gluten* is composed of certain proteine compounds (Fibrine, Caseine, Albumen, Emulsine), containing carbon, oxygen, hydrogen, and nitrogen, with some phosphorus and sulphur. *Vegetable fibrine* is the essential part of the gluten of wheat, and of the cereal grains. It may be procured by treating with ether the glutinous mass left after kneading wheat flour in linen bags under water. *Vegetable caseine* or *legumine* is an essential part of the seeds of Leguminous plants, and also of oily seeds. It may be procured in solution from kidney beans and peas, by bruising them in a mortar with cold water, and straining. *Vegetable albumen* occurs in a soluble form associated with caseine. It forms a small proportion of cereal grains. Wheat is said to contain ⅜ to 1⅓ per cent.; Rye, 2 to 3¾ per cent.; Barley, 1/10 to ½ per cent.; and Oats, ⅕ to ⅓ per cent. It is distinguished by its coagulation at a temperature of 140° to 160°, and by not being precipitated by acetic acid. These three compounds dissolve in a solution of caustic potash; and if to the solution acetic acid is added, the same precipitate is obtained whichever of the three is employed. This precipitate is called Proteine (*πρωτεύω*, I have the first place). Its formula is $C^{48} H^{36} N^{6} O^{14}$. Fibrine is proteine + S. + Ph. Albumen is proteine + S^2 + Ph. Caseine is proteine + S. *Emulsine*, or *synaptase*, is a nitrogenous compound found in certain oily seeds, as in almonds. It exists in the milky emulsion which these seeds form in water, and it is coagulated by acetic acid, and by heat. In bitter almonds, it is associated with a substance called *amygdaline*, on which it acts in a peculiar manner, producing hydrocyanic acid. *Diastase is an azotised* substance procured from malt, and developed during

the germination of plants. It is probably fibrine in an altered state, and it has the power of promoting the conversion of starch into sugar.

311. The azotised products of plants have a similar composition with blood and muscular fibre, and hence their value in the food of man and animals. The following table gives a general view of the quantity of azotised and unazotised matters occurring in certain plants, with the amount of water and inorganic matter:—

	Water.	Azotised matter.	Carbonaceous matter.	Ashes.
Peas	16	29	52	3
Beans	14	31	52	3
Lentils	16	33	48	3
Oats	18	11	68	3
Barley	16	14	69	2
Potatoes	72	2	25	1
Turnips	89	1	9	1

312. The following arrangement is given by Fromberg of the comparative value of various plants as articles of food, taking into account the proteine compounds, and the starch, gum, and saccharine matter which they contain, the highest value being 100:—

Beans	100	Rye	55
Peas	80	Barley	50
Oats	75	Potatoes	45
Wheat	70	Rice	35
Maize	60		

313. As regards the produce of different crops per acre, Johnston gives the following estimate of the nutritive products which they yield:—

	Average produce per acre of tubers and grain.	No. of lbs. of true nutriment in produce of an acre.
Beet, Mangel-wurzel, and Turnip	30 tons	672 lbs.
Beans	30 bushels, or 1980 lbs.	594 —
Potatoes	8 tons	358 —
Peas	20 bushels, or 1160 lbs.	348 —
Barley	36 bushels, or 1872 lbs	243 —
Jerusalem Artichokes	10 tons	224 —
Wheat	25 bushels, or 1500 lbs.	180 —
Oats	30 bushels, or 1200 lbs.	132 —

314. **Fixed Oils** are found in the cells and intercellular spaces of the fruit, leaves, and other parts. Some of these are drying oils, as Linseed oil, from Linum usitatissimum; others are fat oils, as that from Olives (fruit of Olea europæa); while others are solid, as Palm oil. The solid oils or fats procured from plants, are Butter of Cacao, from Theobroma *Cacao; of* Cinnamon, from Cinnamomum

zeylanicum; of Nutmeg, from Myristica moschata; of Coco-nut, from Cocos nucifera; of Laurel, from Laurus nobilis; Palm oil, from Elais guineensis; Shea butter, from Bassia Parkii; Galam butter, from Bassia butyracea; and Vegetable tallow, from Stillingia sebifera in China, from Vateria indica in India, and from Pentadesma butyracea in Sierra Leone. These oils contain a large amount of stearine, and are used as substitutes for fat. Castor Oil, from the seeds of Ricinus communis, differs from other fixed oils in its composition.

315. Decandolle gives the following table to show the quantity of oils got from seeds:—

Hazel-nut	60	per cent.	in weight.	White Mustard	36	per cent.	in weight.
Garden Cress	57	—	—	Tobacco	34	—	—
Olive	50	—	—	Plum	33	—	—
Walnut	50	—	—	Woad	30	—	—
Poppy	48	—	—	Hemp	25	—	—
Almond	46	—	—	Flax	22	—	—
Euphorbia Lathyris	41	—	—	Sunflower	15	—	—
				Buckwheat	14	—	—
Colza	39	—	—	Grapes	12	—	—

316. **Vegetable Wax** is a peculiar fatty matter sometimes found in the stem and fruit of plants. It is procured from several species of Palms, as Ceroxylon Andicola, and Copernicia cerifera, and from the fruit of Myrica cerifera or candle-berry myrtle, and Myrica cordifolia. By boiling these plants in water and compressing them the wax exudes, floats on the water, and may be collected and re-melted. It is of a greenish yellow colour. By saponification it yields stearic, margaric, and oleic acids, along with glycerine. It therefore more closely approximates the character of fat rather than wax. Waxy matter also occurs on the exterior of fruits, giving rise to the *bloom* of grapes, plums, &c., on the outer surface of the bracts of Musa paradisiaca, and on the leaves of many species of Encephalartos. In Cork there exists a fatty body which, when acted upon by nitric acid, yields suberic acid. Chlorophylle, or the green colouring matter of leaves, is allied to wax in its nature, being soluble in ether and alcohol, but insoluble in water.

317. **Volatile or Essential Oils** occur in the stem, leaves, flowers, and fruit of many odoriferous plants, and are procured by distillation along with water. They are called *essences*, and contain the concentrated odour of the plant. They usually exist ready-formed, but occasionally they are formed by a kind of fermentation, as oil of bitter almonds, and oil of mustard. Some of them consist of carbon and hydrogen only, as oil of turpentine, procured from various species of Pinus and Abies; oil of juniper, from Juniperus communis; oil of Savin, from Juniperus Sabina; oil of lemons and oranges, from the rind of the fruit; and oil of neroli, from orange flowers. A second series contain oxygen in addition, as oil of cinnamon, from Cinnamo-

mum zeylanicum; otto or attar of roses, from various species of Rose, especially Rosa centifolia; oil of peppermint, from Mentha viridis; oil of caraway, from Carum Carui; oil of cloves, from Caryophyllus aromaticus. Oils of this kind are procured from many Labiatæ, as species of Lavandula, Origanum, Rosmarinus, Thymus; and from the fruit of Umbelliferæ, as species of Anethum, Fœniculum, Coriandrum, Cuminum, Petroselinum, Pimpinella; and from some Compositæ, as species of Anthemis, Pyrethrum, and Artemisia. A third series have also sulphur in their composition, and have a peculiar pungent, often alliaceous smell, with an acrid burning taste, as oil of garlic, and of onion, procured from the bulbs of Allium sativum and Cepa; oil of assafœtida, from Narthex Assafœtida; and oil of Mustard, which is obtained from the seeds of Sinapis nigra, by a kind of fermentation induced by the action of a nitrogenous body, myrosine, on a substance called myronic acid, or myronate of potash, when macerated in water. A similar oil exists in many Cruciferæ, as in Erysimum Alliaria, Armoracia rusticana, and Cochlearia officinalis, and in several Umbelliferæ, yielding gum-resin, as Opoponax, Ferula, Galbanum, &c. Many of the essential oils deposit a solid crystalline matter, called Stearoptene, allied to *camphor*. This latter substance, which consists of carbon, oxygen, and hydrogen, is procured from Camphora officinarum, a native of Japan and India. There is also another kind of camphor, produced in Borneo, by Dryobalanops Camphora.

318. **Resinous Products.**—The milky and coloured juices of plants contain frequently resins mixed with volatile oils, in the form of balsams, besides a quantity of caoutchouc. The resinous substances found in plants, are either fluid or solid. The former may be illustrated by Balsam of Tolu, procured from Myrospermum toluiferum; Balsam of Peru, from Myrospermum peruiferum; Balsam of Copaiva, from various species of Copaifera, especially Copaifera officinalis; Carpathian Balsam, from Pinus Pinea; Strasburg turpentine, from Abies pectinata, or silver fir; Bourdeaux turpentine, from Pinus pinaster; Canada Balsam, from Abies balsamea, or Balm of Gilead fir; Chian turpentine, from Pistacia Terebinthus, &c. The latter may be illustrated by common resin or Colophony, and Burgundy pitch, from Pinus sylvestris; Mastich, from Pistacia Lentiscus; Sandarach, from Callitris quadrivalvis; Elemi, from several species of Amyris; Guaiac, from Guaiacum officinale; Dragon's-blood, from Dracæna Draco, and Calamus Draco; Dammar, from Dammara australis and orientalis; Labdanum, from Cistus creticus, and others; Tacamahaca, from Calophyllum Cadaba, and from Elaphrium tomentosum; Resin of Jalap, from Exogonium Purga; Storax, from Styrax officinale; Benzoin, from Styrax Benzoin; Copal, from Vateria indica, &c.; Lac, from various species of Ficus, as Ficus indica, or benghalensis, after

attacks of Cocci, and from Aleurites laccifera, and Erythrina monosperma; Euphorbium, from Euphorbia officinarum, antiquorum, and canariensis.

319. **Caoutchouc** is in some respects analogous to essential oils. It is found associated with them and resinous matters, in the milky juice of plants. It is procured from various species of Ficus, as Ficus elastica, Radula, elliptica, and prinoides, from Urceola elastica, Siphonia elastica, and Vahea gummifera, by wounding the plants. A kind of caoutchouc, called *gutta percha*, imported from Singapore and Borneo, is procured from Isonandra Gutta, one of the Sapotaceæ. The milky juice of many plants, as of Euphorbiaceæ, Asclepiadaceæ, Apocynaceæ, Artocarpaceæ, and Papayaceæ, contain caoutchouc or gum elastic. Some of these coloured juices are bland, as that produced by the Cow-tree (Galactodendron utile); others are narcotic, as those of Poppy and Chelidonium; others are purgative, as Gamboge; others diuretic, as Taraxacum.

320. **Organic Acids** are produced by processes going on in living plants, and exist in vegetable juices combined often with peculiar bases and alkaloids. Thus Citric acid occurs in the fruit of the orange, lemon, lime, red currant, &c.; Tartaric acid, in the juice of the grape, and in combination with potash in tamarinds; Malic acid, in the fruit of the apple, gooseberry, mountain ash; Tannic acid or Tannine, in oak bark and nut-galls; Gallic acid, in the seeds of Mango; Meconic acid, in the juice of Papaver somniferum; Kinic acid, in the bark of various species of Cinchona. Besides these, there are numerous others, which are characteristic of certain species or genera. To these may be added Hydrocyanic acid, as found in Prunus Laurocerasus, &c., and Oxalic acid, which exists in combination with potash in Rumex acetosa, and Acetosella, Oxyria reniformis, Oxalis Acetosella, and in combination with lime in Rhubarb, and many species of Parmelia and Variolaria.

521. **Alkaloids or Organic bases** are azotised compounds found in living plants, and generally containing their active principles. They occur usually in combination with organic acids. Quinine and Cinchonine exist in the bark of Cinchona, the former predominating in yellow bark, the latter in pale bark; Morphine, Narcotine, Codeine, Thebaine, and Narceine, occur in the juice of Papaver somniferum; Solanine is an alkaloid found in many species of Solanum, as Solanum tuberosum, nigrum, and Dulcamara; Veratrine exists in Veratrum Sabadilla and album; Aconitine in Aconitum Napellus; Strychnine in Strychnos Nux-vomica, Sancti Ignatii, Colubrina and Tieuté; Brucine also in Nux-vomica, or False Angustura bark; Atropine in Atropa Belladonna; Bebeerine in Nectandra Rodiei; Piperine in Piper longum and nigrum; Emetine in Cephäelis Ipecacuanha; Caffeine (Theine and Guaranine) in Coffea arabica, Thea Bohea and viridis, Paullinia

sorbilis, and Ilex paraguayensis; Theobromine in the seeds of Theobroma Cacao or chocolate; besides numerous others of less importance. These Alkaloids are often found in plants having poisonous properties.

322. **Colouring matters** are furnished by many plants, either directly or by a process of fermentation. *Yellow* colouring matters are procured from the roots of Curcuma longa or Turmeric, from the pulp surrounding the seeds of Bixa orellana (arnotto), from the stem of the Gamboge plant (Hebradendron Cambogioides), and various species of Garcinia, as Garcinia Cambogia and elliptica, from the flowers of Carthamus tinctorius (safflower), from the stigmata of Crocus sativus (saffron), from a kind of Mulberry (Morus tinctoria), from Reseda Luteola (weld), and from some Lichens, as Parmelia parietina (parietin or chrysophanic acid). *Red* colouring matters are produced from the root of Anchusa tinctoria (alkanet), from Pterocarpus santalinus, Dracæna Draco (Dragon's-blood), the root of Rubia tinctorum or madder (alizarine), the root of Morinda citrifolia (Sooranjee), Hæmatoxylon campechianum (logwood), Cæsalpinia braziliana (Brazil wood), from Camwood, also from Carthamus tinctorius (Carthamine), and from some Lichens, as Roccella tinctoria (Archil and Litmus). *Blue* colouring matters are furnished by the flowers and fruits of many plants, and from the leaves of some, by chemical action. *Indigo*, a most valuable dye, is procured by fermentation from various species of Indigofera, as Indigofera tinctoria, Anil, cœrulea and argentea, as well as from Wrightia tinctoria, Marsdenia tinctoria, Nerium tinctorium, and Gymnema tingens, &c. The plants in full flower are cut and put into vats with water, fermentation takes place, and a peculiar substance is formed, which, by absorption of oxygen, becomes blue. The best and the largest quantity of Indigo is produced in the Delta of the Ganges. Several Lichens yield nitrogenous colouring matters, which give blue and purple colours with alkalies, etc. Lecanora tartarea yields Cudbear (Gyrophoric acid).

SECTION III.—ORGANS OF REPRODUCTION.

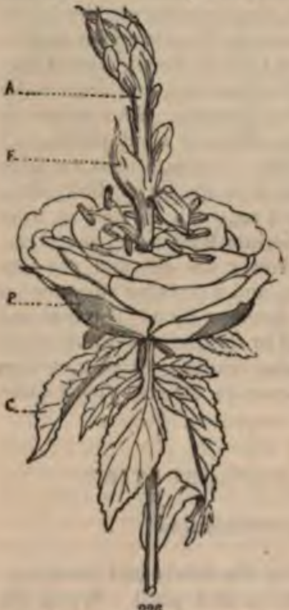
STRUCTURE, ARRANGEMENT, AND FUNCTIONS.

323. The reproductive organs consist of the flower and its appendages, the *essential* parts being the stamens and pistil. When the flower, or at least the essential organs, are conspicuous, the plants are called *Phanerogamous* (φανερὸς, conspicuous, and γάμος, union or marriage), or Flowering plants; when they are inconspicuous, the plants are *Cryptogamous* (κρυπτὸς, concealed, and γάμος, union or marriage), or Flowerless plants. The former include Exogens and Endogens, the latter Acrogens and Cellular plants. On careful examination it

will be found that the organs of reproduction and nutrition are modifications of each other. The parts of the flower, as regards their development, structure, and arrangement, may all be referred to the leaf as a type. They commence like leaves in cellular projections, in which fibro-vascular tissue is ultimately formed; they are arranged in a more or less spiral manner, and they are often partially or entirely converted into leaves.

1.—INFLORESCENCE, OR THE ARRANGEMENT OF THE FLOWERS ON THE AXIS.

324. The arrangement of the flowers on the axis, or the ramification of the floral axis, is called *Inflorescence* or *Anthotaxis* (ἄνθος, a flower, and τάξις, order). Flower-buds, like leaf-buds, are produced in the axil of leaves, which are called floral leaves or bracts. A flower-bud has not in ordinary circumstances any power of extension by the development of its central cellular portion. In this respect it differs from a leaf-bud. In some cases, however, of monstrosity, especially seen in the Rose (fig. 226) and Geum, the central part, A, is prolonged, and bears leaves or flowers. In such cases the flowers are usually abortive, the essential organs being so altered as to unfit them for their functions. Such metamorphoses confirm Goethe's doctrine, that all the parts of the flower are altered leaves.



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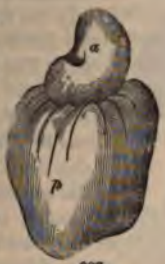
325. The general axis of inflorescence, is sometimes called *rachis* (ῥάχις, the spine); the stalk supporting a flower, or a cluster of flowers, is a *peduncle* (*pes*, a foot) (fig. 231 *a'*); and if small branches are given off by it, they are called *pedicels* (fig. 231 *a''*). A flower having a stalk is called *pedunculate* or *pedicellate* (fig. 231); one having no stalk is *sessile* (fig. 237). In describing a branching inflorescence, it is common to speak of the Rachis as the *primary* floral axis, its branches as the *secondary* floral axes, their divisions as the *tertiary* floral axes, and so on; thus avoid-

Fig. 226.—Proliferous or monstrous Rose, showing the prolongation of the axis beyond the flowers. *c*, Calyx transformed into leaves. *p*, Petals multiplied at the expense of the stamens, which are reduced in number. *f*, Coloured leaves representing abortive carpels. *a*, Axis prolonged, bearing an imperfect flower at its apex.

ing any confusion that might arise from the use of the terms *rachis*, *peduncle*, and *pedicel*.

326. **The Peduncle** assumes various forms. It is cylindrical, compressed, and grooved; simple, bearing a single flower, as in Primrose; and branched, as in London-pride. It is sometimes large and succulent, as in the Cashew (fig. 227 *p*), in which the peduncle forms the large coloured expansion supporting the nut; spiral, as in Cyclamen and Vallisneria (fig. 228); spiny, as in Alyssum spinosum. Sometimes the floral axis is shortened, assuming a flattened, convex, or concave form, and bearing numerous flowers, as in the Artichoke, Daisy, and Fig. In these cases it is called a *Receptacle* or *Phoranthium* (φορέω, I bear, and ἄνθος, flower), or *Clinanthium* (κλίνη, a bed, and ἄνθος, flower).



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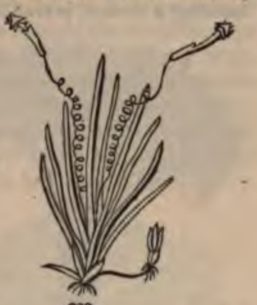

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327. The *Floral axis* sometimes assumes a leaf-like or *phylloid* (φύλλον, a leaf, and εἶδος, form) appearance, bearing numerous flowers at its margin, as in Xylophylla longifolia (fig. 229), and in Ruscus; or it appears as if formed by several peduncles united together so as to become a fasciated axis, as in the Cockscomb (fig. 230), in which the flowers form a peculiar crest at the apex of the flattened peduncles. Adhesions take place between the peduncle and the bracts or leaves of the plant, as in the Lime tree, Helwingia, Chailletia, several species of Hibiscus, and in Zostera. The adhesion of the peduncles to the stem accounts for the extra-axillary position of flowers, as in many Solanaceæ; when this union extends for a considerable length along the stem, several leaves may be interposed between the part where the peduncle becomes free, and the leaf whence it originated, and it may be difficult to trace the connection.

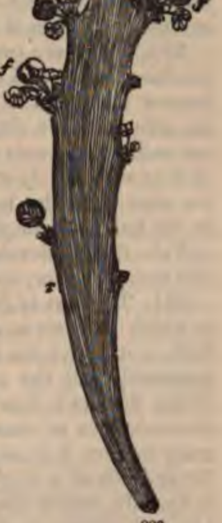

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Fig. 227.—Fruit of Cashew (*Anacardium occidentale*). *p*, Enlarged peduncle. *a*, Fruit or nut.

Fig. 228.—Pistilliferous plant of Vallisneria spiralis, showing spiral peduncles or flower-stalks, by the uncoiling of which the flowers reach the surface of the water, previous to fertilization.

Fig. 229.—Leaf-like (*phylloid*) flattened peduncle, *r*, of Xylophylla longifolia. *f f f*, Clusters of flowers developed in a centrifugal or cymose manner.

328. The peduncle occasionally becomes abortive, and in
bearing a flower, is transformed into a tendril (¶ 201); at oth
it is hollowed at the apex, so a
rently to form the lower part
outer floral envelope, as in Eschsc

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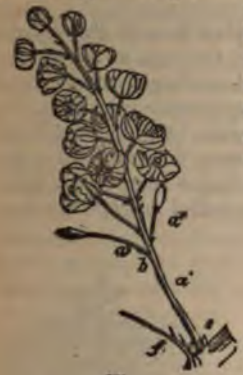
329. The termination of the pe
or the part on which the whorls
flowers are arranged, is called th
lamus or *Torus*. It is the term
of the floral axis. The term *re*
is also sometimes applied to this, w
expanded so as to bear several
or narrowed so as to bear one.
be considered as the growing poin
axis, which usually is arrested
production of the flowers, but
sometimes becomes enlarged and expanded. Thus, in the Ge
it is prolonged beyond the flower in the form of a beak; in the
it is a club-shaped fleshy column (fig. 239, 2, *a*); in the Stra
it becomes succulent and enlarged, bearing the seed-vessels;
Nelumbium it envelops them in the form of a truncated tabular
sion. In some cases it bears the seeds. In some monstrous flo
in Rose and Geum, it is prolonged as a branch bearing leaves (fi

330. There are two kinds of *inflorescence*—one in which flow
produced in the axil of leaves, while the axis continues to be el
beyond them, and to bear other leaves and flowers; the other i
the axis ends in a single terminal flower. In the former, the
are axillary, the axis extends in an indefinite manner, and the
as they successively expand, spring from floral leaves placed hi
the axis than the leaf from which the first flower was dev
In the latter, the single solitary flower terminates and defines t
and the flowers developed subsequently, arise from floral leave
this central flower, and therefore farther removed from the ce

331. The first is *Indeterminate*, *Indefinite*, or *Axillary* inflore
in which the axis is either elongated, continuing to produce
buds as it grows, the lowermost expanding first; or it is flatte
depressed, and the outermost flowers expand first. The ex
of the flowers is thus *centripetal*, that is, from base to apex,
circumference to centre. When this kind of inflorescence p
many flowers, it is *simple*, and proceeds from the development
flower-buds of a single branch. This kind of inflorescence is
in fig. 231, where the leaf from which the cluster of flowers
duced, *f*, represents the bract or floral leaf. The *rachis*, or
axis of the flower, is *a′*; this produces small leaflets, *b*, whic

Fig. 230.—Upper part of flattened or fasciated flowering stem of Celosia cristata (C
having the form of a crest, covered with pointed bracts, and supporting flowers on its

smaller flower-leaves or bractlets, from which peduncles or secondary axes spring, bearing each single flowers. The whole inflorescence is the product of one branch, the lower flowers having expanded first, and bearing fruit, while the upper are in bud, and the middle are in full bloom. In fig. 232, the same kind of inflorescence is shown on a shortened axis, the outer flowers expanding first, and those in the centre last.



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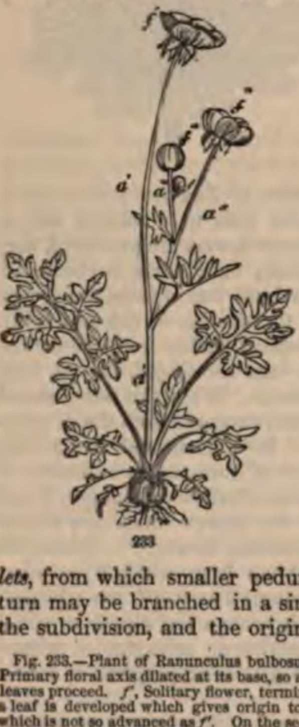
332. The second is *Determinate*, *Definite*, or *Terminal* inflorescence, in which the axis is either elongated and ends in a solitary flower, which thus terminates the axis, and if other flowers are produced, they are secondary, and farther from the centre; or the axis is shortened, and produces at once a number of flower-buds, but of these the central flower expands first, being in fact the termination of the axis, while the other flowers are developed in succession farther from the centre. The expansion of the flowers is in this case *centrifugal*, that is, from apex to base, or from centre to circumference. When this inflorescence produces many flowers, it is *compound*, and proceeds from the development of the buds of several branches. It is illustrated in fig. 233, where a representation is given of a plant of Ranunculus bulbosus; *a'* is the primary axis swollen at the base in a bulb-like manner, *b*, and with roots proceeding from it. From the leaves which are radical proceeds the axis ending in a solitary terminal flower, *f'*. About the middle of this axis there is a leaf or bract from which a secondary floral axis, *a''*, is produced, ending in a single flower, *f''*, less advanced than the flower, *f'*. This secondary axis bears a leaf also from which a tertiary floral axis is produced, *a'''*, bearing an unexpanded solitary flower, *f'''*. From this tertiary axis a fourth is in progress of forma-

Fig. 231.—Raceme of Barberry (*Berberis vulgaris*), produced in the axil of a leaf or bract, *f*, which has been transformed into a spine, with two stipules, *s*, at its base. *a'*, Primary floral axis, bearing small alternate bracts, *b*, in the axil of which the secondary axes, *a'' a''*, are produced, each terminated by a flower. The expansion of the flowers is centripetal, or from base to apex; the lower flowers have passed into the state of fruit, the middle are fully expanded, and those at the top are still in bud. Indeterminate simple inflorescence.

Fig. 232.—Head of flowers or glomerulus of Scabiosa atro-purpurea. The inflorescence is simple and indeterminate, and the expansion of the flowers centripetal, those at the circumference opening first.

tion. Here f' is the real termination of the axis, and this flower then expands first, the other flowers being developed centrifugally on separate axes. It is a compound inflorescence.

333. **Indefinite Inflorescence.**—The simplest form of this inflorescence is when single flowers are produced in the axils of the ordinary leaves of the plant, the axis of the plant elongating beyond them, as in Veronica hederifolia, Vinca minor, and Lysimachia nemorum. The ordinary leaves in this case become floral leaves, by producing flower-buds in place of leaf-buds. In place of solitary flowers there is often an elongated floral axis or peduncle arising from a more or less altered leaf or bract, and bearing numerous leaflets, called *bracteoles* or *bractlets*, from which smaller peduncles are produced, and those in their turn may be branched in a similar way. According to the nature of the subdivision, and the origin and length of the flower-stalks, there



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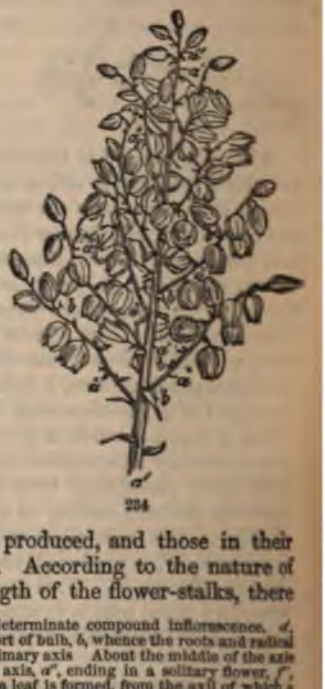

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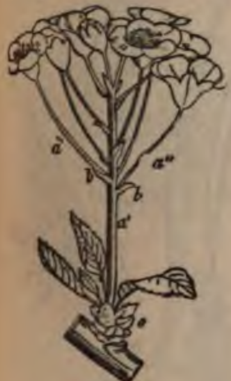
Fig. 233.—Plant of Ranunculus bulbosus, showing determinate compound inflorescence. a', Primary floral axis dilated at its base, so as to form a sort of bulb, b, whence the roots and radical leaves proceed. f', Solitary flower, terminating the primary axis About the middle of the axis a leaf is developed which gives origin to a secondary axis, a'', ending in a solitary flower, f'', which is not so advanced as f'. On the secondary axis a leaf is formed, from the axil of which a tertiary axis, a''', proceeds, ending in a flower, f''', which is still in bud. On this axis another floral leaf and bud is in the progress of formation.

Fig. 234.—Panicle or branching raceme of Yucca gloriosa. a', Primary axis or rachis. a'', Secondary axes or smaller peduncles. a''', Tertiary axes or pedicels bearing flowers. $b\,b\,b\,b$, Bracts and bractlets, in the axil of which the axes are produced. The inflorescence is indeterminate, and consists of a series of racemes on a common axis, a'. The expansion of the whole inflorescence is centripetal, and such is also the case with each of the racemes forming it, the flowers at the base of the axes opening first.

arise numerous varieties of floral arrangements. When the primary peduncle or floral axis, as in fig. 231 a, is elongated, and gives off pedicels, a'', of nearly equal length ending in single flowers, a *raceme* or *cluster* is produced, as in Currant, Hyacinth, and Barberry. If the secondary floral axis gives rise to tertiary ones, the raceme is branching, and forms a *panicle*. In fig. 234 is represented a panicle of Yucca gloriosa, a' being the primary axis or rachis with bracts, giving off numerous secondary axes, a'', which in their turn develop tertiary axes, a''', the development in each of the secondary axes being centripetal, and b b b b being the bracts from which the separate axes are produced. If the peduncles in the middle of a dense panicle are longer than those at the extremities, a *thyrsus* is produced, as in Lilac. If in a raceme the lower flower-stalks are elongated, and come to nearly a level with the upper, a *corymb* is formed, which may be



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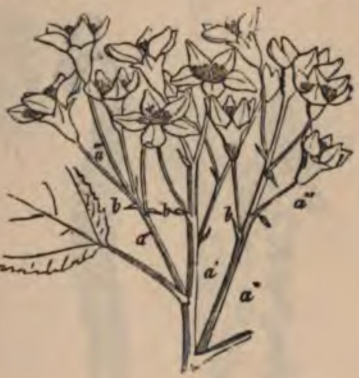

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simple, as in fig. 235, where the primary axis, a', divides into secondary axes, a'' a'', which end in single flowers; or *compound*, as in fig. 236, where the secondary axes again subdivide.

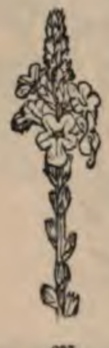
334. If the peduncles or secondary axes are very short or awanting, so that the flowers are sessile, a *spike* is produced, as in Plantago and Verbena officinalis (fig. 237). The spike sometimes bears unisexual flowers, usually staminiferous, the whole falling off by an articulation, as in Willow or Hazel (fig. 238), and then it is called an *amentum* or *catkin;* at other times it becomes succulent, bearing

Fig. 235.—Corymb of Cerasus Mahaleb, produced in the axil of a leaf which has fallen, and terminating an abortive branch, at the base of which are modified leaves in the form of scales, e. a', Primary axis, or peduncle, or rachis, producing alternate bracts, b b, from the axil of which secondary axes or pedicels, a'' a'', arise, each bearing a single flower. The evolution or expansion of the flowers is centripetal.

Fig. 236.—Compound or branching corymb of Pyrus torminalis. a', Primary axis. a'' a'', Secondary axes. a''' a''', Tertiary axes or pedicels bearing the flowers directly. b b b, Bracts.

numerous flowers surrounded by a sheathing bract or spatha, and then it constitutes a *spadix*, which may be simple, as in Arum maculatum (fig. 239), or branching, as in Palms. A spike bearing female flowers only, and covered with scales, is either a *strobilus*, as in the Hop; or a *cone*, as in the Fir (fig. 201). In grasses, there are usually numerous sessile flowers arranged in small spikes, called *Locustæ* or *spikelets*, and these clusters are either set closely along a central axis or rachis, or they are produced on a branched panicle.

335. If the primary axis, in place of being elongated, is depressed or flattened, it gives rise to other forms of indefinite inflorescence.



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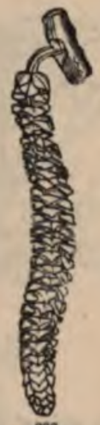

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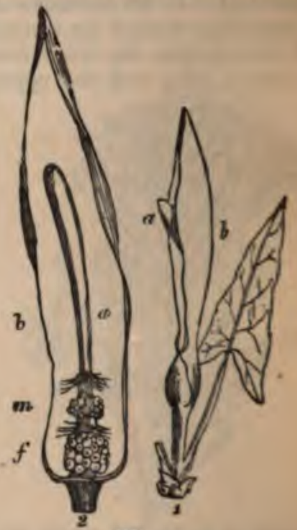

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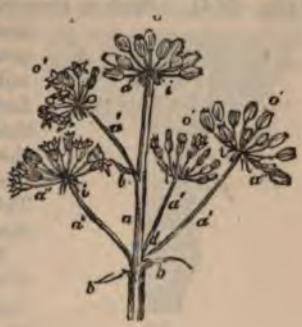
When the axis is so shortened that the secondary axes or peduncles arise from a common point, and spread out like *radii* of nearly equal length, each ending in a single flower, or dividing again in a similar

Fig. 237.—Spike of Verbena officinalis, showing sessile flowers on a common rachis; the inflorescence indeterminate, and the evolution of the flower centripetal. The flowers at the lower part of the spike have passed into fruit, those towards the middle are in full bloom, and those at the top are only in bud.

Fig. 238.—Amentum or catkin of Hazel (*Corylus Avellana*), consisting of an axis or rachis covered with bracts in the form of scales (*squamæ*), each of which covers a male flower, the stamens of which are seen projecting beyond the scale. The catkin falls off in a mass, separating from the branch by an articulation,

Fig. 239.—Spadix or succulent spike of Arum maculatum. 1, Exhibits the sagittate leaf, the spatha or sheathing bract, *b*, rolled round the spadix, the apex of which, *a*, is seen projecting. 2, Shows the spatha, *b*, cut longitudinally, so as to display the spadix, *a*. *f*, Female flowers at the base. *m*, Male flowers. On the spadix there are numerous abortive flowers indicated by hair-like projections

radiating manner, an *Umbel* is produced, as in figs. 240 and 241. In fig. 240 the floral axes, a', a', a', end in simple umbels, o', o', o', and the umbels are called *stipitate* or *stalked*; while in fig. 241 the primary floral axis, a', is very short, and the secondary axes, a', a', come off from it in a radiating or umbrella-like manner, and end in small umbels, o', which are called *partial umbels* or *umbellules*, to distinguish them from the *general umbel* arising from the primary axis. This inflorescence is seen in Hemlock, and other allied plants, which are hence called Umbelliferous.



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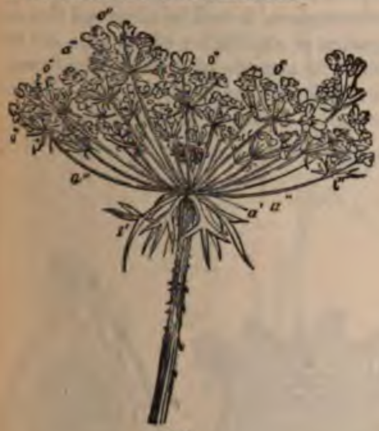

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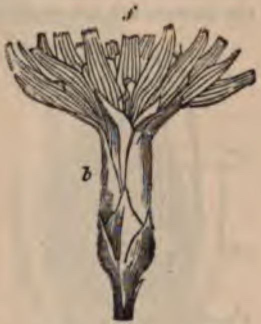

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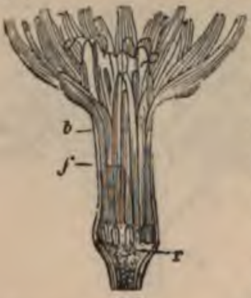
336. If there are numerous flowers on a flattened convex or slightly concave receptacle, having either very short pedicels or none, a *capitulum* (a head) or *anthodium* (ἄνθος, a flower, ὁδὸς, a way or method), or *calathium* (καλάθιον, a small cup), is formed, as in Dandelion,

Fig. 240.—Several umbels, o' o' o' o', of Aralia racemosa. a, General axis or the apex of the branch terminated by a single umbel farther advanced than the rest. a' a' a' a', Axes arising from it, which are secondary as respects the general axis, a; each of them bears an umbel, and as regards this inflorescence they are primary. a'' a'' a'', Secondary axes, or the radii of the umbel. b b b, Bracts placed alternately on the general axis. d, Shows a double bud proceeding from the axil of one of these bracts, and thus giving rise to two-stalked or stipitate umbels. i i i, Verticillate bracts, forming involucres at the base of the radii of the umbels.

Fig. 241.—Compound umbel of Carrot (*Daucus Carota*). a', Pimary axis shortened and depressed, so as to present a convex surface. a'' a'', Secondary axes or radii of the general umbel, each ending in a partial umbel or umbellule, o'' o'' o'' o''. a''' a''', Tertiary axes or radii of the partial umbels or umbellules. i', Pinnatipartite bracts, forming the general involucre. i'' i'', Simple bracts, forming the partial involucre or involucel.

Fig. 242.—Capitulum, Anthodium, or Head of flowers of Scorzonera hispanica. b, Imbricated bracts, forming an involucre. f, Florets or small flowers on the receptacle, having a centripetal evolution.

Daisy, and other composite plants (figs. 242 and 243); or a *glomerulus* * (a ball), as in Scabiosa (fig. 232), and in Dipsacus (fig. 244). Such a receptacle or flattened peduncle may sometimes be folded so as to enclose partially or completely a number of flowers (generally unisexual), giving rise to the peculiar inflorescence of Dorstenia (fig. 245), or to that of the Fig (fig. 246), where *f* indicates the flowers placed on the inner surface of the receptacle, and provided with bracteoles. This inflorescence has been called *Hypanthodium* (ὑπό, under, and ἄνθος, a flower).



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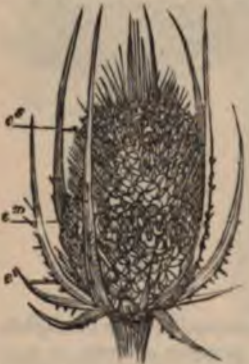
337. On reviewing these different kinds of inflorescence, it will be observed that the elongation or shortening of the axis, and the presence or absence of stalks to the flowers, determine the different varieties. Thus, a spike is a raceme in which the flowers are not stalked, the umbel a raceme in which the primary axis is shortened, the capitulum or head a spike in which the same shortening has taken place.



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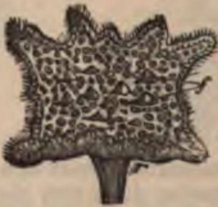

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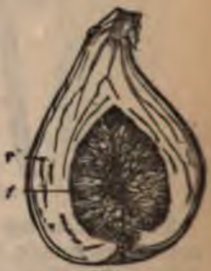

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338. **Definite Inflorescence.**—The simplest form of this inflorescence

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* By some this term is applied to the centrifugal inflorescence of certain Urticaceæ, Chenopodiaceæ, and Juncaceæ.

Fig. 243.—The same Capitulum cut vertically. *r*, The Receptacle, Phoranthium, or the flattened and depressed apex of the peduncle, bearing the florets, *f*, which are surrounded by bracts, *b*.

Fig. 244.—Inflorescence of Dipsacus sylvestris. Glomerulus, or head of flowers, each of which is separated by long pointed bracts. The flowers are evolved in a centripetal manner. *e i*, The first expanded, followed by those at *e m*, while those at the apex, *e s*, are in bud.

Fig. 245.—Inflorescence of Dorstenia Contrayerva, consisting of a broad slightly concave receptacle, *r*, on which numerous male and female flowers, *f*, are placed.

Fig. 246.—Inflorescence of Fig (*Ficus Carica*), showing the hollow receptacle, *r*, or peduncle, which forms the fruit covered with flowers, *f*, of various kinds.

is seen in Anemone nemorosa (fig. 247), or in Gentiana acaulis (Gentianella), where the axis terminates in a single flower; and if other flowers are produced, they arise from the leaves below the first-formed flower. When numerous flowers are produced, and the axes are much shortened, it is sometimes difficult to understand this mode of inflorescence. It may be distinctly traced, however, in plants with opposite leaves, in which the different axes are clearly developed. In fig. 248 is represented the flowering branch of Erythræa Centaurium. Here the primary axis, *d'*, ends in a flower, *f'*, which has passed

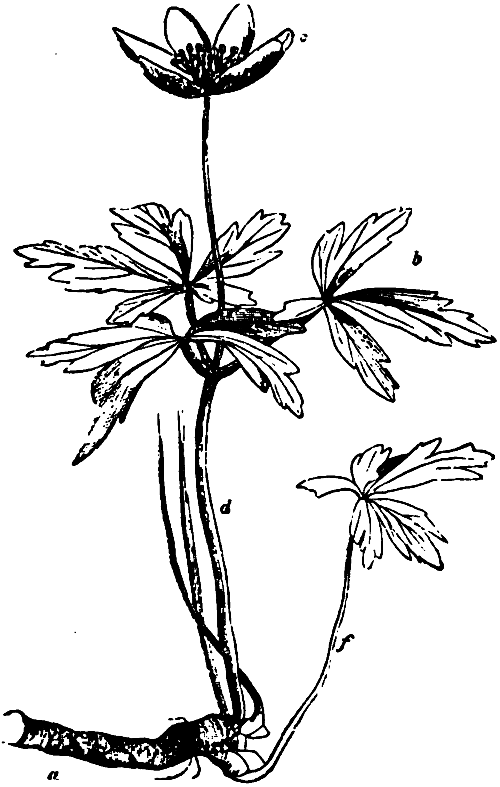

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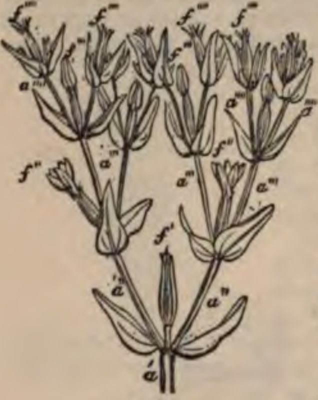
Fig. 247.—Anemone nemorosa. *a*, Subterranean stem. *f*, Leaf. *d*, Floral axis producing bracts, *b*, which form a three-leaved involucre. *e*, Solitary flower terminating the axis. Inflorescence determinate.

A

into the state of fruit. At its base two leaves are produced, each of which is capable of developing buds. In the Gentiana acaulis these leaves rarely produce buds, but in the present plant they generally do. The buds so produced are flower-buds, and constitute secondary axes, a'' a'', ending in single flowers, f'' f'', which thus are terminal and solitary; and at the base of these axes a pair of opposite leaves is produced, giving rise to tertiary axes, a''' a''' a''', ending in single flowers, f''' f''' f''', and so on. The divisions in this case always take place by two, or in a *dichotomous* (δίχα, in two ways, and τέμνω, I cut) manner. Had there been a whorl of three leaves in place of two, the division would have been by three, or *trichotomous* (τρίχα, in three ways).



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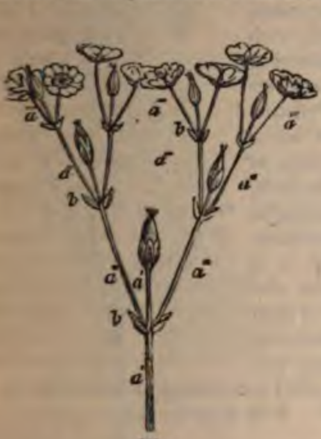
339. When the leaves become very small, and are transformed into true bracts, this whole system forms a single inflorescence, and has received the name of *cyme*. As the definite inflorescence occurs in a marked degree in the cyme, it has hence been called *cymose;* and the cyme itself, according to its divisions, has been characterized as dichotomous or trichotomous. In figs. 249 and 250, the cyme is represented in two species of Cerastium, belonging to the natural order Caryophyllaceæ, in which cymose inflorescence is of general occurrence. The leaves in the figures are small bracts giving origin to flower-buds in the same way as in fig. 248; the flowers at a' a' being the termination of the primary axis and expanding first, the others being subsequently developed in a centrifugal order. In some of the Pink tribe, as Dianthus barbatus, Carthusianorum, &c., in which the peduncles are short, and the flowers closely approximated, with a centrifugal expansion, the inflorescence has received the name of *fascicle.* A similar inflorescence is seen in such plants as Xylophylla longifolia (fig. 229). When the axes become very much shortened, the arrangement is more complicated in appearance, and the nature of the inflorescence is indicated by the order of opening of the flowers. In Labiatæ, as in the Dead nettle (Lamium), the flowers are produced at the axil

Fig. 248.—Flowering branch of Erythræa Centaurium. a', Primary axis. a'' a'', Two secondary axes. a''' a''' a''', Tertiary axes, four in number. a'''' a'''' a'''', Quaternary axes, eight in number. f, The flower in various stages of development. f', Solitary flower which has passed into fruit, terminating the primary axis. f'', Flowers less advanced, terminating the secondary axes. f''', Flowers in bud at the extremity of the tertiary axes, and so on. Inflorescence definite or determinate. Evolution of flowers centrifugal.

of each of the leaves, and might be looked upon as ordinary whorls, but on examination it is found that the central flower expands first, and that the expansion is thus centrifugal. The inflorescence is therefore truly cymose, the flowers being sessile, or nearly so, and the clusters are called *verticillasters* (*verticillus*, a kind of screw).



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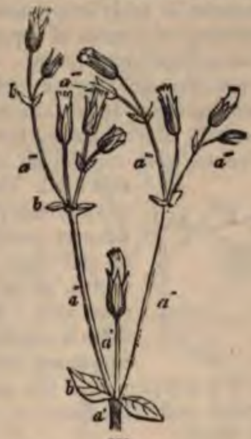

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340. Sometimes the bract on one side of a dichotomous cyme, especially towards the summit of the inflorescence, does not give origin to buds, as seen in the upper flower of fig. 250. When a single bract only is produced, in place of two, there is often an anomalous cymose inflorescence produced, resembling a raceme. Thus, in Alströmeria, as represented at fig. 251, the axis, a', ends in a flower, which has been cut off, and a leaf. From the axil of this leaf, that is, between it and the primary axis, a', a secondary axis, a'', is formed, ending in a flower f'', and producing a leaf about the middle. From the axil of this leaf, a tertiary floral axis, a''', ending in a flower, f''',

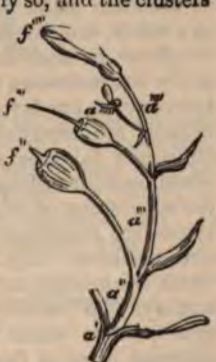

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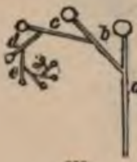
Fig. 249.—Inflorescence of Cerastium grandiflorum. *b b b*, Opposite bracts produced at each of the branchings. The axes are indicated as in last figure. The primary axis, a', ends in a flower which has passed into fruit. Inflorescence determinate. Evolution of flowers centrifugal.

Fig. 250.—Inflorescence of Cerastium tetrandrum. Letters have the same meaning as in the last two figures. In the quaternary axes, a'''', the inflorescence becomes lateral by the non-development of the flower-buds on one side.

Fig. 251.—False raceme of a species of Alströmeria. a' a'' a''' a'''', Separate axes successively developed, which appear to form a simple continuous raceme, of which the axes form the internodes. It is a compound determinate inflorescence, however, with centrifugal evolution. Each of the axes is produced in the axil of a leaf, and is terminated by a flower, f' f'' f''' f'''', opposite to that leaf.

is developed, and so on. Sometimes the bract on the opposite side shows itself, as at *a*. This inflorescence, therefore, although it appears simple and racemose, is truly compound and cymose, consisting of a series of separate axes, with a centrifugal expansion. The flowering branch often exhibits, in such cases, a series of curvations. In certain orders of plants, especially Boraginaceæ, the bracts being alternate, give rise to an inflorescence of this kind. Thus, in fig. 252, *a* is a primary axis, ending in a flower, producing another, *b*, and that, a third, *c*, a fourth, *d*, &c., all on the same side. In such a case there is usually a remarkable curvature resembling the tail of a scorpion, and the cyme is called *scorpioidal* or *helicoidal* (ἕλιξ a spiral, and εἶδος, form) or *gyrate.** It is seen in the forget-me-not (fig. 253).



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341. Instances of both kinds of floral expansion occur occasionally on the same plant. Thus, in Compositæ, the *heads* of flowers taken as a whole, are developed centrifugally, the terminal head first; while the *florets*, or small flowers on the receptacle, open centripetally, those at the circumference first. So also in Labiatæ, the different whorls of inflorescence are developed centripetally, while the florets of the verticillaster are centrifugal. Sometimes this mixed character presents difficulties in cases such as Labiatæ, where the leaves, in place of retaining their ordinary form, become bracts, and thus might lead to the supposition of all being a single inflorescence. In such cases, the cymes are described as spiked, racemose, or panicled, according to circumstances. Fig. 254 represents a panicled cyme of Privet, in which the primary axis, a', gives off secondary axes, a'' a'', whence arise tertiary, a''' a''', ending dichotomously, and producing three-flowered cymes, *c c*, in which the central flower expands first. Fig. 255 is a racemose cyme of Campanula, developed in a very irregular manner, and giving rise to a peculiar mixed inflorescence; a' a' is the primary axis, ending in a flower, f', which has withered, and giving off secondary axes, a'' a'', each terminated by a flower, and developed centripetally, the lowest being most expanded. These are anomalous cases, and not

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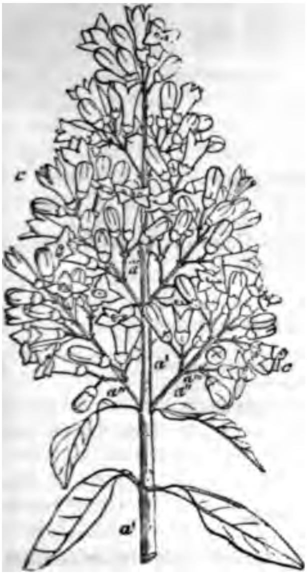
* Schleiden says that this inflorescence is simply a unilateral raceme, having centripetal expansion.

Fig. 252.—Figure to show the formation of a scorpioidal or helicoid cyme, consisting of separate axes, *a b c d e*.

Fig. 253.—Scorpioidal, gyrate, or helicoid cyme of Forget-me-not (*Myosotis palustris*).

easily explained. Such mixed inflorescences, partly definite and partly indefinite, are by no means uncommon.



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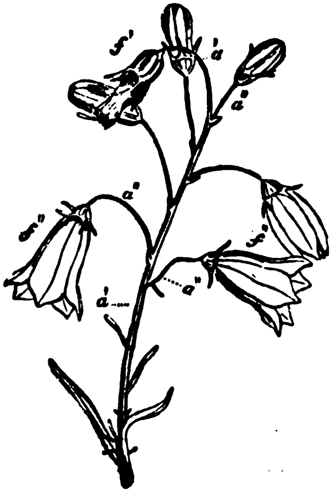

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342. Sometimes flowers proceed from what are called radical leaves; that is, from an axis which is so shortened as to bring the leaves close together in the form of a cluster. From such stems, floral axes are pushed upwards occasionally, bearing single flowers, or flowers in umbels and racemes, as in Primrose, Auricula, Hyacinth, &c. In these cases, the name of *scape* is applied to the flowering stem.

343.—Tabular Arrangement of Inflorescence or Anthotaxis.

A. Flowers Sessile.
  I. Floral Axis elongated.
    1. Axis permanent.
      Spike (Plantago), Locusta or Spikelet (Lolium), Spadix (Arum), Cone (Fir), Strobilus (Hop).

Fig. 254.—Cymose panicle, or Panicled cyme of Privet (*Ligustrum vulgare*). The primary axis, a', gives off secondary axes, a'' a'', which are opposite to each other, and produce tertiary axes, a''' a''', which are dichotomous, and consequently end in small three-flowered cymes, *c c*. Of the three flowers terminating these tertiary axes, the central one expands first, the evolution of the others being centrifugal.

Fig. 255.—Racemose cyme, or Cymose raceme of Campanula a' a', Primary axis, terminated by a flower, f', which has already withered, and is beginning to pass into the state of fruit. a'' a'' a''. Secondary axes, each terminated by flowers, f'', which are more advanced the lower they are in their position.

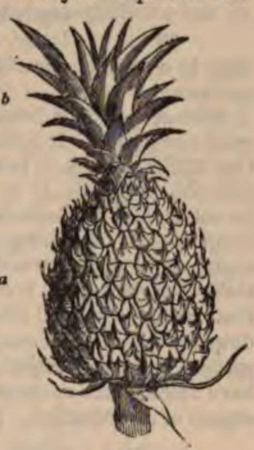
- 2. Axis deciduous.
    - Catkin or Amentum (Willow), Compound Catkin (Male flowers of some Palms).
- II. Floral Axis shortened or depressed (a Receptacle).
    - Capitulum, Anthodium or Calathium (Dandelion).
- B. Flowers Pedicellate.
    - I. Floral Axis elongated.
        - 1. Peduncles simple.
            - *a.* of equal or nearly equal length.
                - Raceme (Currant, Hyacinth).
            - *b.* lowermost longest.
                - Centripetal expansion—Corymb (Ornithogalum).
                - Centrifugal expansion—Fascicle (Pink).
        - 2. Peduncles branched.
            - Panicle (Poa), Thyrsus (Lilac), Anthela (Luzula), Compound Raceme (Plane-tree), Compound Corymb (Milfoil).
    - II. Floral Axis shortened or depressed.
        - 1. Expansion centripetal.
            - *a.* Peduncles very short, Flowers forming a close head.
                - Glomerulus (Armeria, Scabious).
            - *b.* Peduncles nearly equal, radiating from a common centre.
                - Peduncles simple—Simple Umbel (Astrantia, Ramsons).
                - Peduncles branched—Compound Umbel (Hemlock).
        - 2. Expansion centrifugal.
            - *a.* Peduncles simple—Verticillaster (Lamium).
            - *b.* Peduncles branched—Cyme (Elder).

2.—Bracts or Floral Leaves.

344. Flowers, with the exception of the terminal flower, arise from the axil of leaves, called *Bracteæ*, *bracts* or *floral leaves*. The term bract is properly applied to the leaf, from which the primary floral axis, whether simple or branched, arises, while the leaves which arise on the axis between the bract and the outer envelope of the flower are *bracteoles* or *bractlets*. The two are distinct, but are often used indiscriminately in ordinary descriptions. Bracts sometimes do not differ from the ordinary leaves, and are then called *leafy*, as in Ajuga. Like leaves, they are either entire or divided. In general, as regards their form and appearance, they differ from the ordinary leaves of the plants, this difference being greater in the upper than in the lower branches of an inflorescence. They are distinguished by their position at the base of the flower or flower-stalk. When the flower is sessile, the bracts are often applied closely to the calyx, and may thus be confounded with it; intermediate between the leaf and the petal, and at times partaking of the characters of each. *Bracts* appear in many instances to be intended by nature as protecting organs, within or beneath which the young flowers in their earliest stage of growth may be secured.

345. When bracts become coloured, as in Amherstia nobilis, Euphorbia splendens, and Salvia splendens, they may be mistaken for parts of the corolla. They are sometimes mere scales or threads, and at other times they are abortive, and remain undeveloped, giving rise to the *ebracteated* inflorescence of Cruciferæ and some Boraginaceæ. Sometimes flower-buds are not produced in their axil, and then they are *empty*. A series of empty coloured bracts terminates the inflorescence in Salvia Horminum. The smaller bracts or bracteoles, which occur among the subdivisions of a branching inflorescence, often produce no flower-buds, and thus anomalies occur in the floral arrangements.

346. Bracts are occasionally persistent, remaining long attached to the base of the peduncles, but more usually they are deciduous, falling off early by an articulation. In some instances they form part of the fruit, becoming incorporated with other organs. Thus, the cones of Firs (fig. 201) and the strobili of the Hop, are composed of a series of bracts arranged in a spiral manner, and covering fertile flowers; and the scales on the fruit of the Pine-apple (fig. 256 *a*), are of the same nature. In Amenta or catkins (fig. 238), the bracts are called *squamæ* or scales. As regards their arrangement, they follow the same law as leaves; being alternate, opposite, or verticillate.



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347. At the base of the general umbel in umbelliferous plants, a whorl of bracts often exists called a *general involucre* (fig. 241 *i'*), and at the base of the smaller umbels or umbellules, there is a similar leafy whorl called *involucel* or *partial involucre* (fig. 241 *i''*). In Compositæ, the name involucre is applied to the leaves, scales, or phyllaries surrounding the head of flowers (fig. 242 *b*), as in Dandelion, Daisy, and Artichoke. This involucre is often composed of several rows of leaflets, which are either of the same or different forms and lengths, and often lie over each other in an imbricated manner. When the bracts are arranged in two rows, and the outer row is perceptibly smaller than the inner, the involucre is sometimes said to be *caliculate*, as in Senecio. The leaves of the involucre are spiny in Thistles and in Dipsacus (fig. 244 *e i*), and hooked in Burdock. Such whorled or verticillate bracts may either remain separate (*polyphyllous*), or be united by adhesion (*gamophyllous*), as in many species of Bupleurum, and in Lavatera. In the acorn they form the *cupula* or cup (fig. 257 *c*), and they also

Fig. 256.—Fruit of Pine-apple (*Ananassa sativa*), composed of numerous flowers united into one mass; the scales, *a*, being modified bracts or floral leaves. The crown, *b*, consists of a prolongation of the axis bearing leaves, which may be considered as a series of empty bracts, *i, e*, bracts not producing flowers in their axil.

form the husky covering of the Hazel-nut. In the yew the bracts form a succulent covering of the seed.

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348. When bracts become united together, and overlie each other in several rows, it often happens that the outer ones do not produce flowers or become empty or sterile. In the artichoke, the outer imbricated scales or bracts are in this condition, and it is from the membranous white scales or bracts (*paleæ*) forming the choke attached to the edible receptacle, that the flowers are produced. The sterile bracts of the Daisy occasionally produce *capitula*, and give rise to the Hen-and-Chicken Daisy. In place of developing flower-buds, bracts may, in certain circumstances, as in proliferous or viviparous flowers, produce leaf-buds.

349. A sheathing bract enclosing one or several flowers, is called a *spatha* or *spathe*. It is common among Endogens, as Narcissus, Arum (fig. 239 *b*), Palms. In some Palms it is 20 feet long and encloses 200,000 flowers. It is often associated with the spadix, and may be coloured as in Calla or Richardia æthiopica. When the spadix is compound or branching, as in Palms, there are smaller spathes surrounding separate parts of the inflorescence, to which the name *spathellæ* has sometimes been given. The spathe protects the flowers in their young state, and often falls off after they are developed, or hangs down in a withered form, as in some Palms, Typha, and Pothos. In grasses, the outer scales have been considered as sterile bracts, and have received the name of *glumes*, and in Cyperaceæ bracts enclose the organs of reproduction.

8.—The Flower and its Appendages.

350. **The Flower** consists of whorled leaves placed on an axis, the internodes of which are not developed. This shortened axis is the *Thalamus* or *torus*. There are usually four of these whorls or verticils:—1. The outer one called the *calyx*. 2. The *corolla*. 3. The *stamens*. 4. The most internal one, the *pistil*. Each of these consist normally of several parts, which, like leaves, follow a law of alternation. Thus, the flower of Crassula rubens (fig. 258) presents a calyx, *c c*, composed of five equal pieces arranged in a whorl; a corolla, *p p*, also of five parts,

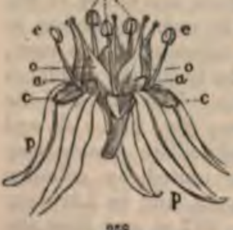

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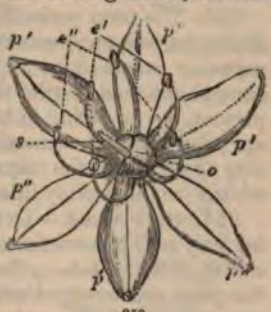
Fig. 257.—Acorn, or Fruit of the Oak. *c*, Cupula or cup, formed by the union of numerous bracts or floral leaves, the free points of which are seen arranged in a spiral manner.

Fig. 258.—Flower of Crassula rubens. *c c*, Foliola of calyx or sepals. *p p*, Petals. *e e*, Stamens. *o o*, Carpels, each of them having a small scale-like appendage, *a*, at their base.

placed in a whorl within the former, and occupying the intervals between the five parts of the calyx; five stamens, *e e e*, in the space between the parts of the corolla, and consequently opposite those of the calyx; and five parts of the pistil, *o o*, which follow the same law of arrangement. Again, in Scilla italica, the parts are arranged in sets of three in place of five, as shown in fig. 259, where *p′ p′ p′* are three parts of the external whorl; *p″ p″ p″*, three of the next whorl; *e′*, an outer row of stamens; *e″*, an inner row; *o*, the pistil formed of three parts. It is distinctly seen in these instances, that the parts of the flower are to be regarded as leaves arranged on a depressed or shortened axis.

351. When all the parts of the flower are separate, and normally developed, there is no difficulty in tracing this arrangement; but in many cases it is by no means an easy matter to do so, on account of changes produced by the union of one part to another, by degeneration, by the abortion or non-development of some portions, and by the multiplication or folding of others.* Of the four whorls noticed, the two outer (calyx and corolla), are called *floral envelopes;* the two inner (stamens and pistil), are called *essential organs.* When both calyx and corolla are present, the plants are *Dichlamydeous* (δὶς, twice, and χλαμύς, a covering); occasionally one or both become abortive, and then the flower is either *Monochlamydeous* (μόνος, single), having a calyx only, or *Achlamydeous* (α, privative) or naked, having only the essential organs, and no floral envelope.



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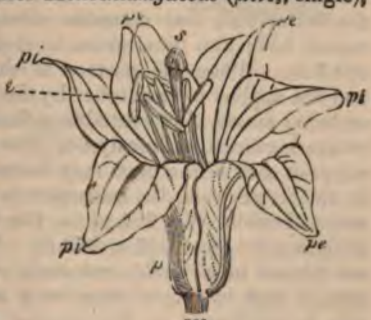

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352. The **Floral Envelopes** consist of the calyx and corolla. In most cases, especially in Exogens, these two whorls are easily distinguishable, the first being external and green, the latter internal, and more or less highly coloured. If there is only one whorl, then, whatever its colour

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* At the conclusion of the remarks on the organs of reproduction, notice is taken of various metamorphoses produced in flowers by the causes above specified.

Fig. 259.—Flower of Scilla italica. *p′ p′ p′*, Three external leaflets, or divisions of the perianth or Perigone. *p″ p″ p″*, The three internal leaflets. *e′*, Stamens, opposite to the first or external leaflets. *e″*, Stamens, opposite the second or internal leaflets. *o*, Ovaries united together into one. *s*, Three styles, consolidated so as to form one.

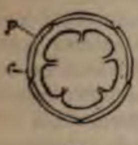
Fig. 260.—Flower of White Lily (*Lilium album*). *p*, Perianth or Perigone, having three parts exterior, *p e*, alternating with three interior, *p i*. *e*, Stamens, having versatile anthers attached to the top of the filaments. *s*, Stigma at the apex of the style.

or degree of development, it is the calyx. Sometimes, as in many Endogens, the calyx and corolla both display rich colouring, and are apt to be confounded. In such cases, the term *Perianth* (περὶ, around, and ἄνθος, flower), or *Perigone* (περὶ and γονή, pistil) has been applied to avoid ambiguity. Thus, in the Tulip, Crocus, Lily, Hyacinth, in place of calyx and corolla, authors speak of the parts of the perianth, although in these plants, an outer whorl (calyx), may be detected, of three parts, and an inner (corolla), of a similar number arranged alternately. Thus, the perianth of the White Lily (fig. 260 *p*), consists of three outer parts, *p e*, alternating with three internal parts, *p i*, surrounding the essential organs, *e*, the stamens, and *s*, the pistil.

353. The term perianth then is usually confined to the flowers of Endogens, whatever colour they present, whether green, as in Asparagus, or coloured, as in Tulip. Some use the term perianth as a general one, and restrict the use of perigone to cases where a pistil is present, not applying it to unisexual flowers in which stamens only are produced. In some plants, as Nymphæa alba (fig. 310), it is not easy to say where the calyx ends, and the corolla begins; as these two whorls pass insensibly into each other.

354. **Flower-bud.**—To the flower-bud, the name *alabastrus* (meaning *rose-bud*) is sometimes given, and its period of opening has been called *anthesis* (ἄνθησις, flower opening), whilst the manner in which the parts are arranged with respect to each other before opening, is the *æstivation* (*æstivus*, belonging to summer), or *præfloration* (*præ*, before, and *flos*, flower). The latter terms bear the same relation to the flower-bud, that vernation does to the leaf-bud, and distinctive names have also been given to the different arrangements which it exhibits. When the parts of a whorl are placed in an exact circle, and are applied to each other by their edges only, without overlapping or being folded, thus resembling the valves of a seed-vessel, the æstivation is *valvate*, as in calyx of Guazuma ulmifolia (fig. 261 *c*). The edges of each of the parts may be turned either inwards or outwards; in the former case, the æstivation is *induplicate*, as in corolla of Guazuma ulmifolia (fig. 261 *p*), in the latter *reduplicate*, as in calyx of Althæa rosea (figs. 262 *c*, 263 *c*). When the parts of a single whorl are placed in a circle, but each of them exhibits a torsion of its axis, so that by one of its sides it overlaps its neighbour, whilst its side is overlapped in like manner by that standing next to it, the æstivation is *twisted* or *contorted*, as in Corolla of Althæa rosea (figs. 262 *p*, 264 *p*). This arrangement is characteristic of the flower-buds of the Malvaceæ and Apocynaceæ, and it is also seen in the Convolvulaceæ and some Caryophyllaceæ. When the flower expands, the traces of twisting often disappear, but sometimes, as in Apocynaceæ, they remain.

355. In these instances of æstivation, the parts of the verticils are considered as being placed regularly in a circle, and about the same height, and they are included under *circular* æstivation. But there are other cases in which there is a slight difference of level, and then the true spiral arrangement exhibits itself. This is well seen in the leaves of the calyx of Camellia japonica (fig. 265 *c*), which cover each other partially like tiles on a house. This æstivation is *imbricated*. At other times, as in the petals of Camellia (fig. 265 *p*), the parts envelop each other completely, so as to become *convolute*. This is also seen in a transverse section of the calyx of Magnolia grandiflora (fig. 267), where each of the three leaves embraces that within it. When the parts of a whorl are five, as occurs in many Exogens, and the imbrication is such, that there are two parts external, two internal, and a fifth which partially covers one of the internal parts by its margin, and is in its turn partially covered by one of the external parts, the æstivation is *quincunxial* (fig. 266). This quincunx is common in the corolla of Rosaceæ. Fig. 266 is a horizontal section of the calyx in the flower-bud of Convolvulus sepium, in which the parts are numbered according to their arrangement in the spiral cycle, and the course of the spiral is indicated by a line of points. In fig. 268, a section is given of the bud of Antirrhinum majus, showing the imbricated spiral arrangement. In this case it will be seen, when contrasted with fig. 266, that the part marked 2, by a slight change



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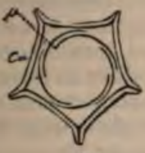

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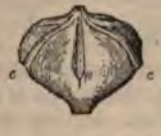

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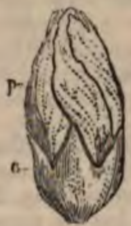

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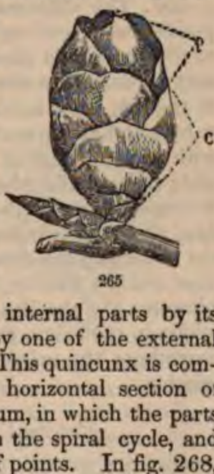

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Fig. 261.—Diagram of calyx, *c*, and corolla, *p*, in the bud of Guazuma ulmifolia. Æstivation of calyx valvate, of petals induplicate.

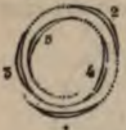
Fig. 262.—Diagram of calyx, *c*, and corolla, *p*, in the flower-bud of Althæa rosea. Æstivation of calyx reduplicate, of petals contorted or twisted.

Fig. 263.—Flower-bud of Althæa rosea in a young state, showing calyx, *c*, still completely enveloping the other parts, and the edges of its divisions touching each other.

Fig. 264.—The same in a more advanced state, where the calycine divisions, *c*, are separated so as to allow the expansion of the corolla, the petals of which, *p*, are contorted in æstivation.

Fig. 265.—Flower-bud of Camellia japonica. *c*, Imbricated sepals of the calyx. *p*, Petals with convolute æstivation.

in position, has become overlapped by 4. In flowers, such as those of the Pea (¶ 379, fig. 292), one of the parts, the vexillum, is often large and folded over the others, giving rise to *vexillary* æstivation, or the carina may perform a similar part, and then the æstivation is *carinal.*



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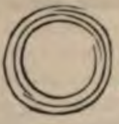
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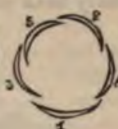

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356. The different verticils often differ in their mode of æstivation. Thus, in Malvaceæ, the corolla is contorted, and the calyx valvate, or reduplicate (fig. 264). In Convolvulaceæ, while the corolla is twisted, and has its parts arranged in a circle, the calyx is imbricated and exhibits a spiral arrangement (fig. 266). In Guazuma (fig. 261), the calyx is valvate, and the corolla induplicate. The circular æstivation is generally associated with a regular calyx and corolla; while the spiral æstivations are connected with irregular as well as regular forms.

357. The different parts of the flower, besides having a certain position as regards each other, bear also definite relations with respect to the floral axis whence they arise. An individual part of a flower may be turned to the one or the other side of the axis, to the right or to the left, in its normal state, and the same will be the case with the corresponding parts of the other flowers. This law often holds good with whole groups of plants, and a means is thus given of characterizing them. If a whorl of the flower consists of four parts, that which is turned towards the floral axis is called *superior* or *posterior*, that next the bract whence the pedicel arises is *inferior* or *anterior*, while the other two are *lateral.* If again, there are five parts of the whorl, then two are inferior, two lateral, and one superior. In plants having blossoms like the Pea, the vexillum, or odd petal, is the superior part; whilst in the calyx, the odd part, by the law of alternation, is inferior. Sometimes the twisting of parts makes an *apparent* change in their position.

External Floral Whorls, or Floral Envelopes.

358. **Calyx.**—The calyx is the external envelope of the flower, and consists of verticillate leaves, called *sepals*, *foliola*, or *phylla*, (*folium*, and φύλλον, a leaf). These calycine leaves are sometimes separate from each other, at other times they are united to a greater or less extent; in the former case, the calyx is *polysepalous* or *polyphyllous* (πολὺς,

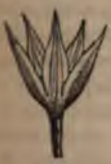
Fig. 266.—Horizontal section of calyx in flower-bud of Convolvulus sepium. Calyx consists of five sepals corresponding to the numbers in the figure, and the line of points indicates the direction of the spiral according to which they are arranged.

Fig. 267.—Arrangement of the three outer leaflets (calyx) in the bud of Magnolia grandiflora, cut transversely; æstivation convolute.

Fig. 268.—Arrangement of the parts of the calyx in the flower of Frogsmouth (*Antirrhinum majus*). The arrangement differs from that in fig. 266, on account of a slight twisting and overlapping of the parts.

many), in the latter *gamosepalous* or *gamophyllous*, *monosepalous* or *monophyllous* (γάμος, union, or μόνος, one). The divisions of the calyx present usually all the characters of leaves, and in some cases of monstrosity they are converted into the ordinary leaves of the plant. This is frequently seen in the Rose (fig. 226 *c*), Pæony, &c. Their structure consists of cellular tissue or parenchyma, traversed by vascular bundles, in the form of ribs and veins, containing spiral vessels, which can be unrolled, delicate woody fibres, and other vessels,—the whole being enclosed in an epidermal covering, having stomata, and often hairs on its outer surface, which corresponds to the under side of the leaf.

359. The venation of the calyx in the great divisions of the vegetable kingdom, is similar to that of their leaves; parallel in Endogens, reticulated in Exogens. The leaves of the calyx are usually entire (fig. 269), but occasionally they are cut in various ways, as in the Rose (fig. 270 *c f*), and they are sometimes hooked at their margins, as in Rumex uncatus (fig. 271 *c i*). In the last-named plant, there are two whorls of calycine leaves, the outer of which, *c e*, are entire, and there are also swellings, *g*, in the form of grains or tubercles on the back of the inner hooked sepals. The outer leaves, *c e*, may be looked upon in such cases as bracts occupying an intermediate place between leaves and sepals. It is rare to find the leaves of the calyx stalked. They usually consist of sessile leaves, in which the laminar portion is only slightly developed, and frequently the vaginal part is alone present. Sepals are generally of a more or less oval, elliptical, or oblong form, with the extremity either blunt or acute. In their direction they are erect or reflexed (with their apices downwards), spreading out-



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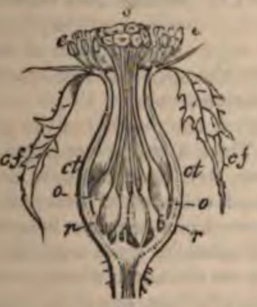

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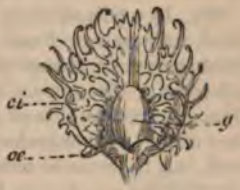

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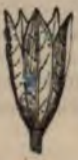
Fig. 269.—Pentaphyllous or pentasepalous calyx of Stellaria Holostea; sepals entire

Fig. 270.—Flower of the Rose, cut vertically. *c t*, Tube of the calyx. *c f*, Limb of calyx divided into leaflets *e e*, Stamens. *o o*, Ovaries, each having a style which reaches beyond the tube of the calyx, and ending in a stigma, *s*.

Fig 271.—Calyx of Rumex uncatus, composed of two verticils or whorls; the outer, *c e*, having short and entire divisions; the inner, *c i*, having larger divisions, which exhibit at the margin narrow hooked projections, and have at their base a granular swelling, *g*.

wards (*divergent* or *patulous*), or arched inwards (*connivent*). They are usually of a greenish colour, and are called *foliaceous* or *herbaceous*; but sometimes they are coloured, as in the Fuchsia, Tropœolum, and Pomegranate, and they are then called *petaloid*. Whatever be its colour, the external envelope of the flower must be considered as the calyx.

360. The nature of the hairs on the calyx gives rise to terms similar to those already mentioned as applied to the surfaces of plants (¶ 60). The vascular bundles sometimes form a prominent rib (figs. 272, 273), which indicates the middle of the sepal, at other times they form several (fig. 274). The venation is useful in pointing out the number of leaves which form a gamosepalous calyx. At the part where two sepals unite, there is occasionally a prominent line, formed by the union of the vessels of each (fig. 274), which divides near the apex into two branches, each following the course of their respective sepals.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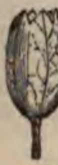
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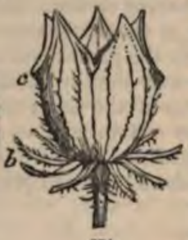

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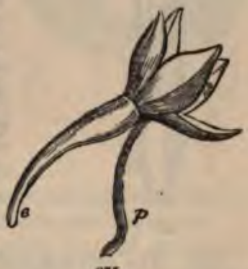
361. In a polysepalous calyx, the number of the parts is marked by Greek numerals prefixed. Thus, a *trisepalous* calyx has three sepals, *pentasepalous* or *pentaphyllous*, five, as in Stellaria Holostea (fig. 269), and so on. The sepals occasionally are of different forms and sizes. Thus, in Aconite, one of them has a peculiar helmet shape, and has been called *galeate* (*galea*, a helmet); some authors regard this as a petal, but it seems to belong to the outer whorl, and is consequently a part of the calyx. In Calcophyllum, one of the sepals enlarges after the corolla falls, and becomes of a fine pink colour.

362. In a monophyllous or gamosepalous calyx, the sepals adhere in various ways, sometimes very slightly, as in Œnothera; and their number is marked by the divisions at the apex. These divisions are either simple projections in the form of acute or obtuse teeth (fig. 273), or they extend about half way, as fissures, the calyx being *trifid* (three-cleft), *quinquefid* (five-cleft), as in Primula elatior (fig. 272), according to circumstances; or they reach to near the base in the form of partitions, the calyx being *tripartite*, *quadripartite*, *quinquepartite*, &c. The adhesion or union of the parts may be complete, and the calyx may be quite entire or *truncate*, as in some Correas, the venation being the chief indication of the different parts. The adhesion is sometimes irregular, some parts uniting to a greater extent than others, thus

Fig. 272.—Quinquefid or five-cleft calyx of Primula elatior or the oxlip.
Fig. 273.—Five-toothed calyx of Silene inflata.
Fig. 274.—Calyx, c, of Hibiscus, with its calculus or epicalyx, b.

forming a two-lipped or *labiate* calyx, which, when the upper lip is arched, becomes *ringent*. The upper lip is often composed of three parts, which are thus posterior or next the axis, while the lower has two, which are anterior. The part formed by the union of the sepals is called the *tube* of the calyx; the upper portion where the sepals are free is the *limb*. Sometimes a monophyllous calyx assumes an angular or prismatic form, as in Lamium and Primula, and then the angles are marked by the midribs of the sepals which form it. Occasionally the calyx has a *globular* form, at other times it is *bell-shaped*, *funnel-shaped*, *turbinate* (like a top), or *inflated*.

363. Occasionally, certain parts of the sepals undergo marked enlargement. In the Violet, the calycine segments (*laciniæ*) are prolonged downwards beyond their insertions, and in the Indian Cress (Tropœolum) this prolongation is in the form of a spur (*calcar*), formed by three sepals (fig. 275 *e*); in Delphinium it is formed by one. When one or more sepals are thus enlarged, the calyx is *calcarate* or *spurred*. In the Pelargonium, the spur from one of the sepals is adherent to the flower-stalk.



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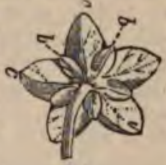
364. In some plants, as the Mallow tribe, the flower appears to be provided with a double calyx, which has been denominated *caliculate*, the outer calyx being the *epicalyx*. In fig. 274, *c* represents the calyx of Hibiscus, and *b* the smaller calyx or epicalyx outside; and in fig. 276, the same thing is shown in Potentilla verna. Many authors look upon the outer calyx as a collection of whorled bractlets, or an involucre placed immediately below the flower. In some cases the projecting teeth between the divisions of the calyx, as in Rosaceæ, are to be traced to the transformed stipules of the calycine leaves. Degenerations take place in the calyx, so that it becomes dry, scaly, and glumaceous (like the glumes of grasses), as in the Rush tribe; hairy, as in Compositæ; and a mere rim, as in some Umbelliferæ and Acanthaceæ, when it is called *obsolete* or *marginate*.



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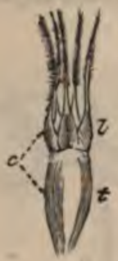
365. In Compositæ, Dipsaceæ, and Valerianaceæ, the tube of the calyx adheres to the pistil, and the limb is developed in the form of hairs, called *pappus*. This pappus is either simple (*pilose*) (fig. 278), or feathery (*plumose*) (fig. 279). In cases where, to the naked eye, the hairs appear to be simple, the application of a lens sometimes exhibits distinct tooth-like projections often irregularly scattered. In

Fig. 275.—Calcarate calyx of Tropœolum or Indian cress. *e*, Spur or calcar. *p*, Pedicel.
Fig. 276.—Calyx, *c c*, of Potentilla verna, with its epicalyx or caliculus, *b b*.

figs. 277, 278, and 279, there are examples of calyces, *c*, the tubes of which, *t*, are united to the pistil, while the limbs, *l*, show the transition from the narrowed thread-like form in Catananche cærulea (fig. 277), to the pilose in Scabiosa atro-purpurea (fig. 278), and thence to the plumose in Pterocephalus palæstinus (fig. 279). In Valeriana, the limb of the calyx at first seems to be an obsolete rim, but as the fruit ripens, it is shown to consist of hairs rolled inwards, which expand so as to waft the fruit.



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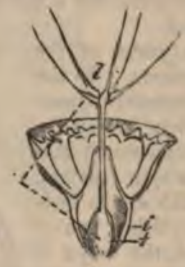

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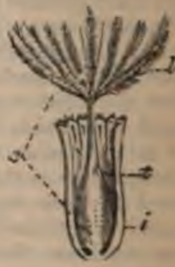

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366. The calyx sometimes falls off before the flower expands, as in Poppies, and is *caducous;* or along with the corolla, as in Ranunculus, and is *deciduous*; or it remains after flowering, as in Labiatæ, Scrophulariaceæ, and Boraginaceæ; or its base only is persistent, as in Datura Stramonium. In Eschscholtzia and Eucalyptus, the parts of the calyx remain united at the upper part, and become disarticulated at the base or middle, so as to come off in the form of a lid or funnel. Such a calyx is *operculate* (*operculum*, a lid), or *calyptrate* (καλύπτρα, a covering). The existence or non-existence of an articulation determines the deciduous or persistent nature of the calyx. In the case of Eschscholtzia, the axis seems to be prolonged so as to form a sort of tube, from which the calyx separates. In Eucalyptus, the calyx consists of leaves, the laminæ or petioles of which are articulated like those of the Orange, and the separation between the parts occurs at this articulation.

367. The tube of the calyx is sometimes united to the pistil, and enlarges subsequently, so as to form a part of the fruit, as in the Apple, Pear, Pomegranate, Gooseberry, &c. In these fruits the limb of the calyx is seen at the apex. Sometimes a persistent calyx increases much after flowering, without being incorporated with the fruit, becoming

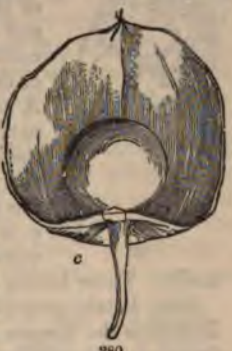
Figs. 277–279.—Examples of calyces, the limbs of which, *l*, gradually pass into the state of hairs or pappus. *c*, Calyx, the tube of which, *t*, is united to the ovary, and forms a narrow column above it, in figs. 278, 279, the limb, *l*, consisting of numerous simple or feathery hairs. *i*, Involucre or gamosepalous bracts cut vertically.

Fig. 277.—Calyx of Catananche cærulea.

Fig. 278.—Calyx of Scabiosa atro-purpurea.

Fig. 279.—Calyx of Pterocephalus palæstinus.

accrescent (*accresco*, I increase), as in various species of Physalis (fig. 280); at other times it remains in a withered or *marcescent* (*marcesco*, I decay) form; sometimes it becomes *inflated* or *vesicular*. In Trifolium fragiferum, the union of the inflated calyces causes the strawberry-like appearance of the head of flowers when in fruit.



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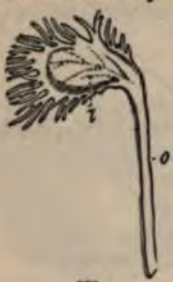
368. **Corolla.**—The corolla is the more or less coloured inner floral envelope, forming the whorl of leaves between the calyx and the stamens. It is generally the most conspicuous whorl. The gay colours and fragrant odours of flowers are resident in it. It is present in the greater number of Exogens. It is composed of parts which are usually disposed in one or more verticillate rows, and which are called *petals* (πέταλον, a leaf). The petals sometimes form a continuous spiral with the calycine segments, but in general they are disposed in a circle, and alternate with the sepals.

369. Petals differ more from leaves than sepals do, and are much more nearly allied to the next whorl or the stamens. In some cases, however, they are transformed into leaves like the calyx, and occasionally leaf-buds are developed in their axil. They are seldom green, although occasionally this colour is met with, as in some Cobæas, Hoya viridiflora, Gonolobus viridiflorus, and Pentatropis spiralis. They are generally white, red, blue, or yellow, or exhibit some colour produced by an intermixture of these. The colouring matter is contained in cells, and differs in its nature from the chlorophylle of the leaves. As regards their structure, petals consist of cellular tissue traversed by true spiral vessels, and thin-walled tubes. In delicate flowers, as Convolvulus and Anagallis, these vessels are easily seen under the microscope. Petals do not usually present numerous layers of cells like the leaves, neither is the epidermis always distinct, although in some instances it may be detached, especially from the surface next the calyx. The cuticle of the petal of a Pelargonium, when viewed with a $\frac{1}{2}$ or $\frac{1}{4}$ inch object glass, shows beautiful hexagons, the boundaries of which are ornamented with several inflected loops in the sides of the cells.

370. On the outer surface of petals, corresponding to the lower side of leaves, stomata are sometimes found. Petals are generally glabrous or smooth; but, in some instances, hairs are produced on their surface. Petaline hairs, though sparse and scattered, present occasionally the same arrangement as those which occur on the leaves: thus, in

Fig. 280.—Accrescent calyx, c, connected with the fruit of Physalis alkekengi.

Bombaceæ they are stellate. Coloured hairs are seen on the petals of Menyanthes, and on the segments of the perianth of the Iris. Although petals are usually very thin and delicate in their texture, they occasionally become thick and fleshy, as in Stapelia and Rafflesia; or dry, as in Heaths; or hard and stiff, as in Xylopia. A petal often consists of two portions—the lower narrow, resembling the petiole of a leaf, and called the *unguis* or *claw;* the upper broader, like the blade of a leaf, and called the *lamina* or *limb.* These parts are seen in the petals of the Pink (fig. 281), where *o* is the claw, and *l* the limb. The claw is often wanting, as in the Rose, and the petals are then *sessile.* Those having a claw are *unguiculate.*



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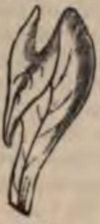
371. Petals, properly so called, belong to Exogenous plants, for in Endogens the flowers consist of a perianth or perigone, which is referred to the calycine envelope. Hence the venation of petals resembles that of exogenous leaves. In the claw the vessels are approximated, as in the petiole, and in the limb they expand. There may be a median vein whence lateral veins go off, at the same or different heights, forming reticulations; or there may be several primary veins diverging from the base of the limb, and forming a sort of fan-shaped venation. At other times the median vein divides into two.

372. According to the development of veins, and the growth of cellular tissue, petals present varieties similar to those already noticed in the case of leaves. Thus the margin is either entire or divided into lobes or teeth. These teeth sometimes form a regular fringe round the margin, and the petal becomes *fimbriated* (*fimbria*, a fringe), as in the Pink (fig. 281); or *laciniated*, as in Lychnis Flos-cuculi; or *crested*, as in Polygala. The median vein is occasionally prolonged beyond the summit of the petals in the form of a long process, as in Strophanthus hispidus, where it extends for seven inches; and at other times it ends in a free point or *cuspis*, and thus becomes *cuspidate;* or the prolonged extremity is folded downwards or inflexed, as in the Umbelliferæ (fig 282), so that the point approaches to the base. If the median vein divides into two, the space between the divisions may be filled up so as to leave only a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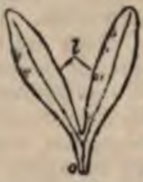

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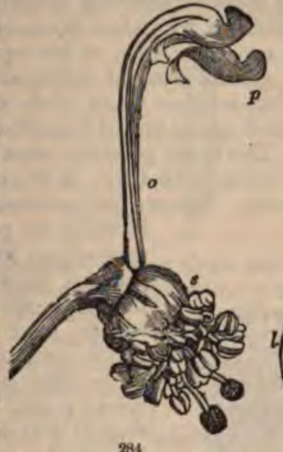
Fig. 281.—An unguiculate petal of Dianthus monspessulanus. *o*, Unguis or claw. *l*, Limb which is fimbriated, or has a fringed margin.

Fig. 282.—A petal of Eryngium campestre, with the apex inflected or turned down towards the base.

Fig 283.—A bipartite petal of Alsine media, or common Chickweed. *l*, The limb split into two *o*, The claw.

slight deficiency, and thus the petal becomes *emarginate;* or the deficiency may be greater, while the limb gradually expands from below upwards, and its extremity becomes two-lobed, so that the petal becomes *obcordate.* If the separation extends to the middle, it is *bifid;* if to near the base, *bipartite*, as in Chickweed (fig. 283 *l*). In the same way as in leaves, the venation of the petals is sometimes unequal, and the cellular tissue is developed more on one side than on the other, thus giving rise to an *oblique* petal.

373. According as the veins proceed in a straight or curved direction, so may the limb of the petal be flat or concave, or hollowed like a boat, *cymbiform* or *navicular* (*cymba*, a boat, and *navis*, a ship), or like a spoon, *cochleariform* (*cochleare*, a spoon). In the case of the navicular petal, the median vein forms a marked keel. In Hellebore, the petals become folded in a tubular form, resembling a horn; in Aconite (fig. 284), some of the petals, *p*, resemble a hollow curved horn, supported on a grooved stalk, while in Columbine (fig. 285), Violet, Snapdragon, and Centranthus, one or all of them are prolonged in the form of a spur, and are *calcarate* (*calcar*, a spur). In Valeriana, Antirrhinum, and Corydalis, the spur is very short, and the corolla or petal is said to be *gibbous* (*gibbus*, a bunch or swelling), or *saccate* at the base. In some Boraginaceæ (fig. 297), there are foldings at the upper part of the tube of the corolla, *r*, causing hollow projections, open on the outside, which might be considered as small internal spurs.



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374. When a petal continues narrow, as if formed by a prolongation of the claw, it is called *linear;* when the limb is prolonged below, so as to form two rounded lobes, it is *cordate*, as in the petal of Genista candicans (fig. 286), and when the lobes are acute, it may be *sagittate* or *hastate.* The meaning of the epithets applied to the forms of petals, will be understood by considering those applied to leaves. In general,

Fig. 284.—Part of the flower of Aconitum Napellus, showing two irregular horn-like petals, *p*, supported on grooved stalks, *o*. These used to be called nectaries. *s*, The whorl of stamens inserted on the thalamus, and surrounding the pistil.

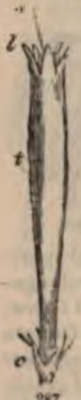
Fig. 285.—Single spurred petal of Aquilegia vulgaris, or common Columbine, formed by a folding of the margins.

Fig. 286.—Cordate or cordiform petal of Genista candicans. *o*, The claw. *l*, The limb.

it may be stated, that the terms refer to the limb of the petal, which is frequently the only portion developed. In the Poppy, the petals have a puckered or corrugated appearance, arising from their delicacy, and the mode in which they are folded in æstivation. Other petals have a *crisp* or *wavy* margin.

375. A corolla rarely consists of one petal, and when this occurs, as in Amorpha, it depends on the abortion or non-development of others. Such a corolla is *unipetalous* (*unus*, one), a term quite distinct from monopetalous (¶ 376). In general, the corolla consists of several petals, equalling the sepals in number, or being some multiple of them. When this is the case, the floral envelopes are said to be *symmetrical;* when, however, by the abortion of some of the petals the numbers do not correspond, then the flower becomes *unsymmetrical.* When alluding to the general symmetry of the flower, the various changes produced by some petals being undeveloped will be considered. A corolla is *dipetalous*, *tripetalous*, *tetrapetalous*, or *pentapetalous*, according as it has two, three, four, or five separate petals.

376. The general name of *polypetalous* (πολὺς, many), is given to corollas having separate petals, while *monopetalous* or *gamopetalous* (μόνος, one, and γάμος, union) is applied to those in which the petals are united. This union generally takes place at the base, and extends more or less towards the apex; in Phyteuma, the petals are united at their apices also. In some polypetalous corollas, as that of the Vine, in which the petals are separate at the base, they adhere by their apices. That a monopetalous corolla consists of several petals united, is shown in such cases as Phlox amœna, some specimens of which have the petals more or less completely disunited, while others exhibit the normal form of coherent petals. When the petals are equal as regards their development and size, the corolla is *regular;* when unequal it is *irregular.* Even although the separate petals are oblique, still, if they are all equally so, as in many Malvaceæ with twisted æstivation, the corolla is regular. The size of the corolla as compared with the calyx, the number, direction, and form of its parts, and their relation to the axis of the plant, require attention.



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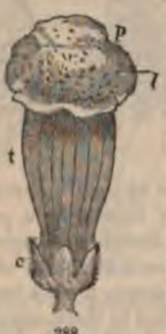

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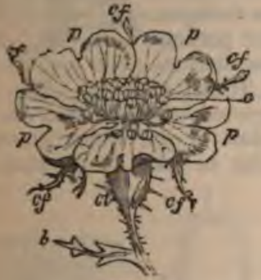
377. When a corolla is monopetalous, it usually happens that the claws, or the lower parts of the petals, are united into a tube (figs. 287, *t*,

Fig. 287.—Regular monopetalous or gamopetalous tubular corolla of Spigelia marylandica. *c*, Calyx. *t*, Tube of the corolla. *l*, Limb of the corolla. *s*, Summit of style and stigma.

Fig. 288.—Irregular gamopetalous or monopetalous corolla of Digitalis purpurea, or Foxglove. *c*, Calyx. *p*, Corolla. *t*, Tube. *l*, Limb.

288 *t*), while the upper parts are either free or partially united, so as to form a common limb (fig. 287 *l*), the two portions being separated by the *faux* or *throat*, which often exhibits a distinct contraction or expansion. The number of parts forming such a corolla can be determined by the divisions, as by the number of teeth, crenations, fissures, or partitions; or if, as rarely happens, the corolla is entire, by the venation. The union may be equal among the parts, or some may unite more than others, leaving gaps between the united portions. Sometimes the tubular portion is bent, as in Lycopsis; at other times the limb is curved at its apex, as in Lamium.



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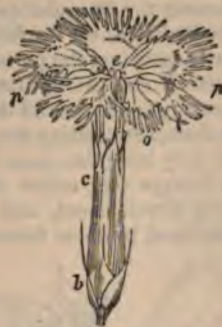

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378. **Regular Polypetalous Corollas.**—Among them may be noticed the *rosaceous* corolla, in which there are five spreading petals, having no claws, and arranged as in the single Rose (fig. 289) and Potentilla; the *caryophyllaceous* corolla, in which there are five petals with long narrow tapering claws, as in many of the Pink tribe (figs. 290, 281); the *alsinaceous*, where the claw is less narrow, and there are distinct spaces between the petals, as in some species of Chickweed; *cruciform*, having four petals, often unguiculate, placed opposite in the form of a cross, as seen in Wallflower (fig. 291), and other plants called *cruciferous* (*crux*, a cross, and *fero*, I bear).

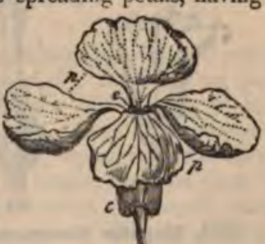

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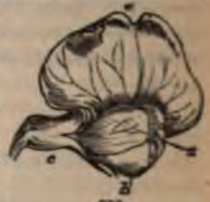
Fig. 289.—Polypetalous flower of Rosa rubiginosa, or the Sweet-brier. *b*, Bract or floral leaf. *ct*, Tube of calyx, which forms the conspicuous part of what is commonly called the fruit. *cf, cf, cf, cf*, Sepals or foliola of the calyx. *p p p p*, Petals without a claw. *e*, Stamens attached to the calyx.

Fig. 290.—Polypetalous flower of Dianthus monspessulanus. *b*, Bracts. *c*, Calyx. *p p*, Petals with their claws, *o*, approximated so as to form a tube.

Fig. 291.—Cruciferous flower of Cherianthus Cheiri, or Wallflower. *c*, Lobes of the sepals; the two external sepals being prolonged inferiorly, so as to form a sort of spur or swelling. *p p*, The four petals arranged like a cross. *e*, The four longer stamens, the summits of the anthers being visible.

379 **Irregular Polypetalous Corollas.**—The most marked of these is the *papilionaceous* (fig. 292), in which there are five petals; one superior (or posterior), turned next to the axis, usually larger than the rest, *e*, and folded over them in æstivation, called the *vexillum* or *standard;* two lateral, *a*, the *alæ* or wings; two inferior (or anterior), partially or completely covered by the alæ, and often united slightly by their lower margins, so as to form a single keel-like piece, *b*, called *carina*, or keel, which embraces the essential organs. This corolla occurs in the Leguminous plants of Britain, or those plants which have flowers like the pea. Among the irregular polypetalous corollas might be included the *orchidaceous*, although it is, properly speaking, the perianth of an Endogen. This perianth consists of three outer portions equivalent to the calyx, and three inner alternating with them, constituting the petals. The latter are often very irregular, some being spurred, others hooded, &c.; and there is always one, called the *labellum* or lip, which presents a remarkable development, and gives rise to many of the anomalous forms exhibited by these flowers.



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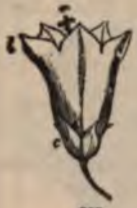

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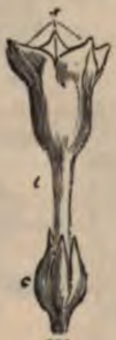

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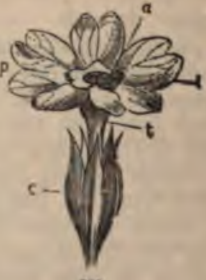

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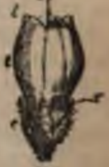

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380. **Regular Monopetalous or Gamopetalous Corollas.**—These are sometimes *campanulate* or *bell-shaped*, as in Campanula rotundifolia

Fig. 292.—Irregular polypetalous corolla in the papilionaceous flower of Lathyrus odoratus, or Sweet-pea. *c*, Calyx. *e*, Vexillum or standard. *a*, Two alæ or wings. *b*, Carina or keel, formed of two petals.

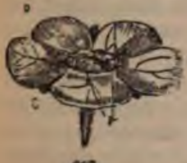
Fig. 293.—Regular monopetalous or gamopetalous campanulate or bell-shaped corolla of Campanula rotundifolia. *c*, Calyx. *l*, Limb of corolla. *s*, Stigma.

Fig. 294.—Regular monopetalous or gamopetalous infundibuliform corolla of Nicotiana Tabacum, or Tobacco. The letters as in fig. 293.

Fig. 295.—Regular monopetalous or gamopetalous hypocrateriform corolla of Primula elatior, or Oxlip. *c*, Calyx. *p*, Corolla. *t* Tube. *l*, Limb. *a*, Anthers.

Fig. 296.—Regular gamopetalous tubular corolla of Symphytum officinale, or common Comfrey. *c*, Calyx. *t*, Tube of corolla. *l*. Limb. *s*, Stigma. *r*, External depressed surface of folds which project into the tube of the corolla.

(fig. 293); *infundibuliform* or *funnel-shaped*, when the tube is like an inverted cone, and the limb becomes more expanded, at the apex, as in Tobacco (fig. 294)); *hypocrateriform* or *salver-shaped*, when there is a straight tube surmounted by a flat spreading limb, as in Primula (fig. 295); *tubular*, having a long cylindrical tube, appearing continuous with the limb, as in Spigelia (fig. 287), and Comfrey (fig. 296); *rotate* or *wheel-shaped*, when the tube is very short, and the limb flat and spreading, as in Myosotis (fig. 297); when the divisions of the rotate corolla are very acute, as in Galium, it is sometimes called *stellate* or *star-like; urceolate* or *urn-shaped*, when there is scarcely any limb, and the tube is narrow at both ends, and expanded in the middle, as in Erica cinerea (fig. 298). Some of these forms may become irregular in consequence of certain parts being more developed than others. Thus, in Veronica, the rotate corolla has one division much smaller than the rest, and in Digitalis there is a slightly irregular campanulate corolla (fig. 288), which some have called *digitaliform.*



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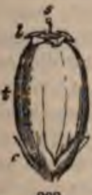

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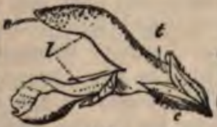

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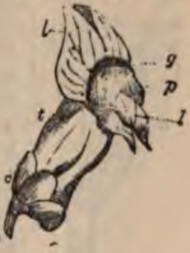

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381. **Irregular Monopetalous or Gamopetalous Corollas.**—Among these may be remarked the *labiate* or *lipped* (fig. 299), having two divisions of the limb in the form of what are called *labia* or lips (from a fancied resemblance to a mouth), the upper one composed usually of two pieces, and the lower of three, separated by a *hiatus* or gap, *l.* In such cases the tube varies in length, and the parts of the calyx follow the reverse order in their union, two sepals being united in the lower lip, and three in the upper. When the upper lip of a labiate corolla is much arched, and the lips separated by a distinct gap, it is called *ringent* (*ringo*, I grin). The Labiate corolla

Fig. 297.—Regular gamopetalous rotate corolla of Myosotis palustris, or Forget-me-not. *c*, Calyx. *p*, Corolla. *r*, Folds of the corolla, forming projections at the upper part of the tube, which are opposite to the lobes of the corolla.

Fig. 298.—Regular gamopetalous urceolate or urn-shaped corolla of Erica cinerea, or cross-leaved Heath. Letters as in fig. 295.

Fig. 299.—Irregular gamopetalous labiate or lipped corolla of Salvia pratensis. *c*, Calyx. *t*, Tube of corolla. *l*, Limb, forming two lips, having a gap or hiatus between them. *s*, Summit of style.

Fig. 300.—Irregular gamopetalous personate or masked corolla of Antirrhinum majus, or Frogsmouth. *c*, Calyx. *t*, Tube of corolla, having a gibbosity or swelling, *a*, at its base. *l*, Limb of corolla. *g*, The faux or mouth closed by a projection of the lower lip, *p*.

characterizes the natural order Labiatæ. In Lobelia, there is
ate corolla, the upper lip of which becomes convex superiorly
split to near the base. When the lower lip is pressed aga
upper, so as to leave only a chink or *rictus* between them, th
is said to be *personate* or *masked* (*persona*, a mask), as in Frog
Snapdragon, and some other Scrophulariaceæ (fig. 300),
projecting portion, *p*, of the lower lip is called the *palate*.
corollas the two lips become hollowed out in a remarkable
as in Calceolaria, assuming a slipper-like appearance, similar
occurs in the labellum of some Orchids, as Cypripedium. S
ceolate (*calceolus*, a slipper) corollas may be considered as c
of two slipper-like lips.

382. When a tubular corolla is split in such a way as to form
like process on one side with several tooth-like projections at
it becomes *ligulate* (*ligula*, a little tongue), c
shaped (fig. 301). This corolla occurs i
composite plants, as in the florets of Da
Daisy, and Chicory. The number of div
the apex indicates the number of united
some of which, however, may be abortive.
sionally, some of the petals become more uni
others, and then this corolla assumes a *bila*
two-lipped form. In Compositæ there a
two kinds of florets associated in the sam
Thus, in the Daisy, there are irregular
white florets on the outside or in the ra
there are regular tubular yellow florets in th
or disc. In Scævola and in Honeysuckle, th
is split down to its base, so as to resemble sc
the ligulate form.

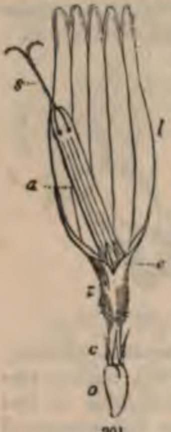

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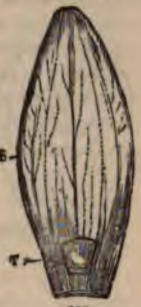
Fig. 301.—Irregular gamopetalous ligulate floret of Catananche cærulea. *c*, Cal
quinquefid limb united inferiorly with the ovary, *o*. *e*, Stamens with united anthers
therous or *syngenesious*), surrounding the style, *s*, with its bifid stigma.

383. **Nectaries and Anomalies in Petals.**—
abnormal appearances occur in the petals
flowers, which received in former days the name of *nectari*
term nectary was very vaguely applied by Linnæus to any pa
flower which presented an unusual aspect, as the crown of N
the processes of the Passion-flower, &c. If the name is ret
ought properly to include only those portions which secrete
like matter, as the glandular depression at the base of the pe
the Fritillary (fig 302 *r*), or on the petal of Ranunculus, o
stamens of Rutaceæ. Some say that in all flowers there is an a
for secreting honey connected with the essential organs of th
and in some way concerned in fertilization, and the nourishme

young seeds. This opinion is particularly supported by Vaucher and Bravais. The sap of Zea Mais is said to contain much saccharine matter before flowering, which ultimately passes to the flower, and disappears from the rest of the plant. What have usually, however, been called Nectaries, are mere modifications of some part of the flower, produced either by degeneration, or by a process of *dilamination* (*dis*, separate, and *lamina*, a blade), or *chorization* (χωϱίζω, I separate). This process, called *unlining* by Lindley, and *deduplication* by Henfrey, consists in the separation of a layer from the inner side of a petal, either presenting a peculiar form, or resembling the part from which it is derived. The parts thus produced are not alternate with the petals or the segments of the corolla, but opposite to them. In these cases, the petals at the lower part consist of one piece, but where the limb and claw separate, or where the tube ends, the vascular layer splits into two, and thus two laminæ are formed, posteriorly and anteriorly, one of which is generally less developed than the other. These dilaminated scales are well seen in Lychnis (fig. 303 *a*), Silene, Cynoglossum, and Ranunculus, and may be considered as formed in the same way as the ligule of grasses (¶ 161). Corollas having these scaly appendages are sometimes denominated *appendiculate*. In other cases, as in Cuscuta, the scales are alternate with the petals, and are not traced to dilamination. This system of dilamination has been applied by the French botanists to all cases in which the parts of whorls become opposite in place of alternate. Lindley and others, however, believing that the law of alternation is the normal one, refer such cases in general to an abortion of a whorl, or to some peculiar arrestment in development, as will be shown under the section of Morphology and Symmetry.



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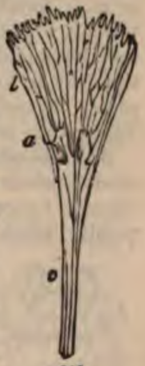

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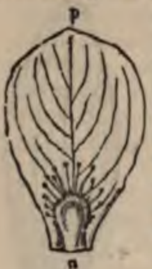
384. In general, the parts called Nectaries, are to be considered as merely modifications of the corolla or stamens. Thus, the horn-like nectaries under the galeate sepal of Aconite (fig. 284 *p*), are modified petals, so also the tubular nectaries of Hellebore. The nectaries of Menyanthes and of Iris, consist of hairs developed on the petals. Those of Parnassia (fig. 304 *n*), and of the Passion-flower, Stapelia, Asclepias, and Canna, are fringes, rays, and processes, which are apparently

Fig. 302.—One of the segments, *s*, of the perianth of Fritillaria imperialis, or Crown Imperial, with a pit or depression, *r*, at its base, containing honey-like matter. The cavity is coloured differently from the rest of the segment, and it is often called a nectary, or a nectariferous gland.

Fig. 303.—Petal of Lychnis fulgens, seen on its inner side. *o*, Claw. *l*, Limb. *a*, An appendage formed by dilamination or chorization. This appendage has been called a nectary.

modifications of stamens, and some consider the crown of Narcissı consisting of a membrane similar to that which unites the stamer Pancratium. It is sometimes difficult to say whe these nectaries are to be referred to the row of corolla or of the stamens. The paraphyses of Passion-flower, the crown of Narcissus, and the cor of Stapelia, are referred sometimes to the one sometimes to the other. In general, they may be to belong to that series with which they are imm ately connected. Some have attempted to give na according to the parts of which they are modificati by prefixing the term *para* (παρὰ, beside, or close and speaking of *paracorolla* and *parastemones*.



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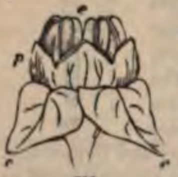
385. Petals are attached to the axis usually narrow base, but occasionally the base is larger than the limb, the Orange flower. When this attachment takes place by an artic tion, the petals fall off either immediately after expansion (*caduc* or after fertilization (*deciduous*). A corolla or petals which are tinuous with the axis and not articulated, as Campanula, Heaths, may be persistent, and remain in a withered or marcescent state w the fruit is forming. A gamopetalous corolla always falls off in piece. Sometimes the base of the corolla remains persistent, a Rhinanthus and Orobanche.

386. **Development of Floral Envelopes.**—The floral envelopes, w monosepalous and monopetalous, first appear in the form of a r whence various cellular projections arise, constituting the sepals petals; when they are polysepalous and polypetalous, the rin wanting. Even when the parts become ultima unequal, as in Digitalis (fig. 288), they form e cellular papillæ when first developed (fig. 3 Barneoud has shown this in the irregular Ran culaceæ, Violaceæ, Orchidaceæ, Labiatæ, Scrop lariaceæ, Leguminosæ, and Polygalaceæ.



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387. In Begoniaceæ, the floral envelope at appears as a continuous ring, having five very e small segments; some of these, especially in the male flowers, disap entirely or become atrophied. All the observations of Barneoud firm Decandolle's statement, that irregular flowers are to be refe to *regular* types, from which they seem to have degenerated. Th appear to be three principal kinds of irregularity among corollas :- Irregularity by simple inequality of development of the sev segments, often along with adhesion or atrophy, or arrest of grow

Fig. 304.—Petal, *p*, of Parnassia palustris, or grass of Parnassus, with a nectary, *n*, which pears to be an abortive state of some of the stamens.

Fig. 305.—Bud of the irregular gamopetalous flower of Digitalis purpurea. *c c*, Calyx. *p*, Co which in its early development is regular. *e*, The stamens at first projecting beyond the co

this is the most common kind. 2. Irregularity of deviation, when the segments, though equal, turn all to the same side, as in ligulate florets. 3. Irregularity by simple metamorphosis of stamina, as in Canna. The irregular corollas of Acanthaceæ, Bignoniaceæ, Gesneraceæ, Lobeliaceæ, and Scrophulariaceæ, are formed at first in a regular manner by equal projections from a sort of cup or ring. Even in Calceolaria, there is at first a scooped-out cup, with four regular and very minute teeth, which are ultimately developed as the corolla; the nascent calyx having also four divisions.

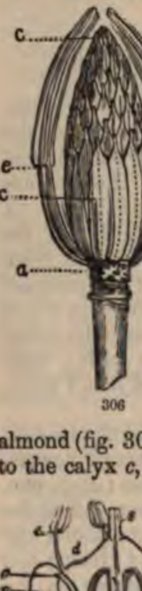
Inner Floral Whorls, or the Essential Organs of Reproduction.

388. These organs are the *stamens* and the *pistil*, the latter containing the seeds or germs of young plants, and corresponding to the female, while the former produces a powder necessary for fecundation, and is looked upon as performing the part of the male. The presence of both is required in order that perfect seed may be produced. A flower may have a calyx and corolla, and yet be imperfect if the essential organs are not present. The name of *hermaphrodite* is given to flowers in which both these organs are found; that of *unisexual* (one sex), or *diclinous* (δὶς, twice, and κλίνη, a bed), to those in which only one of these organs appears,—those bearing stamens only, being *staminiferous* (*stamen*, a stamen, and *fero*, I bear), or male; those having the pistil only, *pistilliferous* (*pistillum*, a pistil, and *fero*, I bear), or female.

389. The absence of one of the organs is due *to abortion or non-development.* When in the same plant there are unisexual flowers, both male and female, the plant is said to be *monoecious* (μόνος, one, and οἰκίον, habitation), as in the Hazel and Castor oil plant; when the male and female flowers of a species are found on separate plants, the term *dioecious* (δὶς, twice) is applied, as in Mercurialis and Hemp; and when a species has male, female, and hermaphrodite flowers on the same or different plants, it is *polygamous* (πολὺς, many, and γάμος, marriage). The term *agamous* (α, privative, and γάμος, marriage) has sometimes been applied to Cryptogamic plants, from the supposed absence of any bodies truly representing the stamens and pistil.

390. **Stamens.**—The stamens (*stamina*) arise from the thalamus or torus within the petals, with which they alternate, forming one or more verticils or whorls, which collectively constitute the *androecium* (ἀνὴρ, a male, and οἰκίον, habitation), or the male organs of the plant, as distinguished from the *gynœcium* (γυνὴ, a female, and οἰκίον, habitation), or female organs of the plant. Their normal position is below the inner whorl or the pistil, and when they are so placed (fig. 306 *e*), they are *hypogynous*; (ὑπὸ, under, γυνὴ, female or pistil). Sometimes they become united to the petals or *epipetalous* (ἐπὶ, upon, and πέταλον, a

leaf), and the insertion of both is looked upon as similar, so that they are still hypogynous, provided they are independent of the calyx and the pistil. In fig. 307, the stamens, *e*, and the petals, *p*, are both below the pistil or ovary, *o*, and separate both from it and the calyx, *c*, and are therefore *hypogynous*. When the stamens are inserted on the calyx, that is, become united to it to a greater or less height above the base of the pistil, then they become lateral as it were in regard to it, and are *perigynous*, (περί, around). This is shown in the flower of almond (fig. 308), in which the petals, *p*, and the stamens, *e*, are united to the calyx *c*, while the pistil is free. When the union of the parts of the flower is such that the stamens are inserted upon the ovary, they are *epigynous* (ἐπί, upon or above). In this case, the whorls are usually so incorporated, that the stamens appear also to come from the calyx. In the Orchis tribe, where the stamens adhere completely to the pistil, and when united extend above the ovary, they are said to be *gynandrous*. In Aralia spinosa (fig. 309), all the whorls,



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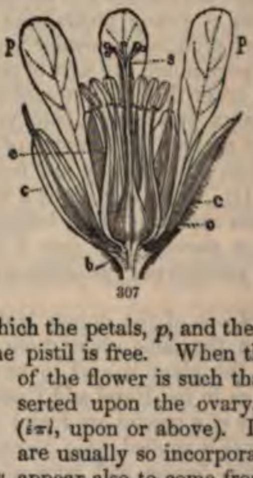

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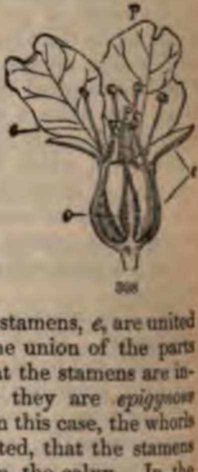

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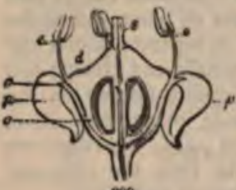

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Fig. 306.—Central part of the flower of Liriodendron tulipifera, the tulip-tree, composed of carpels, *c c*, which together form the pistil. They cover the upper part of the axis, *a*, and below them are inserted numerous stamens, some of which are seen, *e e*. These stamens are hypogynous and extrorse.

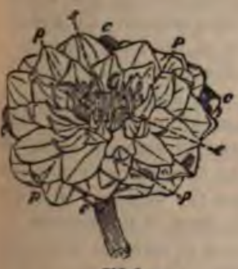
Fig. 307.—Section of a flower of Geranium robertianum. *c c*, Calyx. *p*, Petals. *s*, Stamens. Pistil composed of ovary, *o*, and style and stigmata, *s*. *t*, Torus or thalamus. The petals and stamens are hypogynous, and the latter are monadelphous.

Fig. 308.—Section of the flower of the Almond-tree. The letters indicate the same parts as in the last figure. The petals and stamens are perigynous. The pistil is free.

Fig. 309.—Section of the flower of Aralia spinosa. Letters as in last figure. The petals and stamens are epigynous, attached to a large disk, *d*, which covers the summit of the ovary. The ovary is adherent to the calyx, and has been laid open to show its loculaments and pendulous ovules.

calyx, c, petals, p, and stamens, e, are united to the pistil, and the two latter whorls appear to rise from the point where the calyx joins the upper part of the pistil. These arrangements of parts have given rise to certain divisions in classification, to be afterwards particularly noticed. Decandolle, for instance, applies the term *thalamifloræ*, to plants having the parts of the corolla and androecium independent of each other, and all the whorls inserted immediately into the torus or thalamus; *calycifloræ*, to those where the petals are separate, and the stamens are inserted directly on the calyx; *corollifloræ*, to those in which the united petals bear the stamens.

391. The stamens vary in number, from one to many hundred. Like the other parts of the flower, they are modified leaves resembling them in their structure, development, and arrangement. They consist of cellular and vascular tissue. They appear at first in the form of cellular projections, and are arranged in a more or less spiral form. In their general aspect they have a greater resemblance to petals than to the leaves, and there is often seen a gradual transition from petals to stamens. Thus, in Nymphæa alba, or the White Water-lily (fig. 310, 2), *c* represents a sepal, which gradually passes into the petals, *p*, and these in their turn become modified so as to form the stamens, *e*, which are more or less perfect as we proceed from without inwards, or from 1 to 5. When flowers become double by cultivation, the stamens are converted into petals, as in the Pæony, Camellia, Rose, Anemone, and Tulip; and in these instances, the changes from one to the other may be traced in the same way as in the Water-lily.



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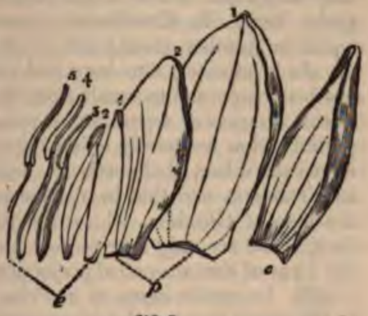

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Fig. 310, 1.—Flower of Nymphæa alba, or White Water-lily. *c c c c*, The four foliola of the calyx or sepals. *p p p p*, Petals. *e*, Stamens. *s*, Pistil.

Fig. 310, 2.—Parts of the flower separated to show the transition from the green sepals of the calyx, *c*, and the white petals of the corolla, *p*, to the stamens, *e*. The latter present changes from their perfect state, 5, through intermediate forms, 4, 3, 2, and 1, which gradually resemble the petals.

392. When there is only one whorl, the stamens are usually equal in number to the sepals or petals, and are arranged opposite to the former, and alternate with the latter. The flower is then *isostemonous* (ἴσος, equal, and στήμων, a stamen). When the stamens are not equal in number to the sepals or petals, the flower is *anisostemonous* (ἄνισος, unequal). When there is more than one whorl of stamens, then the parts of each successive whorl are alternate with those preceding it. The staminal row is more liable to multiplication of parts than the outer whorls. If the stamens are double the sepals or petals as regards number, the flower is *diplostemonous* (διπλόος, double); if more than double, *polystemonous* (πολὺς, many). In general, when the stamens are normally developed, and are more numerous than the sepals and petals, they will be found arranged in several whorls, and their parts multiples of the floral envelopes. Thus, if a flower has five sepals, five petals, and twenty stamens, the latter are arranged in four alternate rows, having five in each. Although this is the usual law, yet various changes take place by abortion, arrestment of development, and other circumstances leading to abnormal growth. In this way the stamens may neither be equal to, nor a multiple of, the floral envelopes, and they may even be less numerous, so that the flower is *miostemonous* (μείων, less). In Cruciferous plants, while the petals and sepals are equal in number, (four,) and alternate in arrangement, the stamens are six in number, four long and two short; this imparity of numbers has been supposed to result from the splitting of the long stamens by lateral chorisis or separation, a presumption favoured by the fact, that partial union frequently exists between the two long stamens placed next each other, that teeth are found only on the outer side of these long stamens, and that in many cruciferæ but four stamens exist. In the case of Gloxinia, where the parts of the flower are arranged in fives, there are only four perfect stamens, but the fifth one is seen in the form of a small conical projection from the base of the corolla.

393. In certain cases, as in Primula, the row of stamens is opposite to the petals forming the gamopetalous corolla. This opposition is by many looked upon as caused by the non-appearance of an outer row of stamens; by others it is considered as produced by chorization or separation of laminæ from the petals, which become altered so as to form stamens, a view which is thought to be confirmed by their development taking place before the petals; by a third party, each petal is looked upon when fully developed as formed by the halves of two contiguous petals, and thus the stamens are considered as being really alternate with the original petals.

394. When the stamens are under twenty, they are called *definite*, and the flower is *oligandrous* (ὀλίγος, few, and ἀνὴρ, male or stamen); when above twenty, they are *indefinite* or *polyandrous* (πολὺς, many), and are marked ∞. The number of stamens is indicated by the Greek

numerals prefixed to the term *androus:* a flower with one stamen being *monandrous* (μόνος, one); with two, *diandrous* (δίς, twice); with three, *triandrous* (τρεῖς, three); with four, *tetrandrous* (τετρὰς, four); with five, *pentandrous* (πέντε, five); with six, *hexandrous* (ἕξ, six); with seven, *heptandrous* (ἑπτὰ, seven); with eight, *octandrous* (ὀκτὼ, eight); with nine, *enneandrous* (ἐννεά, nine); with ten, *decandrous* (δέκα, ten); with twelve, *dodecandrous* (δώδεκα, twelve). These terms will be referred to when treating of the Linnæan system of classification.

395. A stamen consists of two parts—a contracted portion, usually thread-like, equivalent to the petiole of the leaf, and termed the *filament* (*filum*, a thread); and a broader portion, representing the folded blade of the leaf, termed the *anther* (ἀνθηρὸς, belonging to a flower), which contains a powdery matter, called *pollen*. The filament is no more essential to the stamen than the petiole is to the leaf, or the claw to the petal. If the *anther* is absent, the stamen is abortive, and cannot perform its functions. The anther is developed before the filament, and when the latter is not produced the anther is sessile (*sessilis*, sitting), or has no stalk, as in the Mistleto.

396. **The Filament**, when structurally considered, is found to consist of a thin epidermis, on which occasionally stomata and hairs occur, and of a layer of cellular tissue enclosing a bundle of spiral vessels, which traverses its whole length, and terminates at the union between the filament and the anther. The filaments of Callitriche verna are said to have no vessels. The filament is usually, as its name imports, filiform or thread-like, cylindrical, or slightly tapering towards its summit. It is often, however, thickened, compressed, and flattened in various ways. It sometimes assumes the appearance of a petal, or becomes *petaloid* (πέταλον, a leaf or petal, and εἶδος, form), as in Canna, Maranta, Nymphæa alba (fig. 310, 2); occasionally it is *subulate* (*subula*, an awl), or slightly broadened at the base, and drawn out into a point like an awl, as in Butomus umbellatus; and at other times it is *clavate* (*clava*, a club), or narrow below and broad above, like the club of Hercules, as in Thalictrum. In place of tapering, it happens, in some instances, as in Tamarix gallica (fig. 311), Peganum Harmala, and Campanula, that the base of the filament is dilated much, and ends suddenly in a narrow thread-like portion. In these cases, the base may represent the sheath or vagina of the petiole, and, like it, may give off stipulary processes in a lateral direction. Sometimes the filament is forked, or divided at the apex into branches or teeth. In Allium there are three teeth, the central one of which bears the anther.

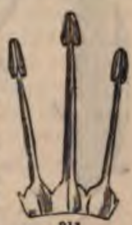

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Fig. 311.—Three out of the ten stamens of Tamarix gallica, united together by the dilated bases of their filaments.

397. The filament varies much in length and in firmness. The length bears a relation to that of the pistil, and to the position of the flower, whether erect or drooping; the object being to bring the anther into more or less immediate contact with the upper part of the pistil, so as to allow the pollen to be scattered on it. The filament is usually of sufficient solidity to support the anther in an erect position; but sometimes, as in Grasses, Littorella, and Plantago, it is very delicate and capillary (*capillus*, a hair), or hair-like, so that the anther is pendulous. The filament is usually continuous from one end to the other, but in some cases it is bent or jointed, becoming *geniculate* (*genu*, a knee); at other times, as in the Pellitory, it is spiral. It is frequently colourless; but, in many instances, it exhibits different colours. In Fuchsia and Poinciana, it is red; in Adamia and Tradescantia virginica, blue; in Œnothera and Ranunculus acris, yellow.

398. Hairs, scales, teeth, or processes of different kinds are sometimes developed on the filament. In Tradescantia virginica, or Spiderwort, the hairs are beautifully coloured, and moniliform (*monile*, a necklace) or necklace-like. These hairs exhibit movements of rotation (¶ 278). Such a filament is bearded or stupose (*stupa*, tow). At the base of the filament, certain glandular or scaly appendages are occasionally produced, either on its internal or external surface. These may be either parts of a whorl, to be afterwards noticed under the name of the Disk, or separate prolongations from the filament itself. In fig. 313, *a* represents such a staminiferous appendage found on the inner side of the base of the filament, *f*, which is hence called *appendiculate*, or sometimes *strumose* (*struma*, a swelling). The processes noticed in the Boraginaceæ as modified petals (fig. 312 *a*), may be considered external appendages of the filaments, the stamen being regarded as the lamina of a petal.

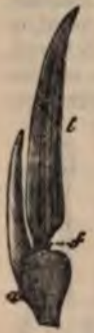

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Fig. 312.—Stamen of Borago officinalis. *f*, Appendiculate filament. *a*, Appendage prolonged in the form of a horn-like process. *l*, Lobes of the anther.

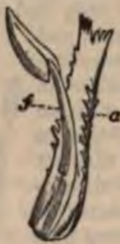

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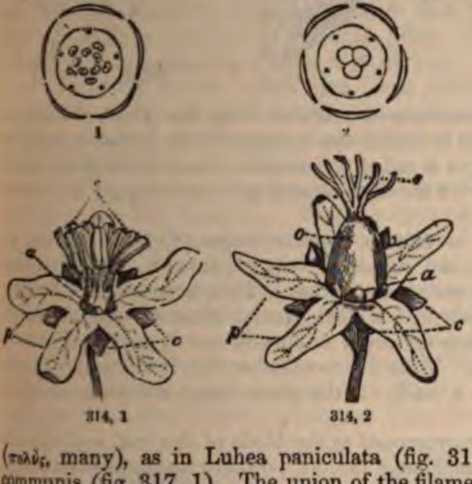
Fig. 313.—Stamen of Zygophyllum Fabago. *f*, Filament, connected with a broad scaly appendage, *a*.

399. Filaments are usually articulated to the torus, and the stamen falls off after fertilization; but in Campanula and other plants, they are continuous with the torus, and the stamen remains persistent, although in a withered state. Certain changes are produced in the whorl of stamens by adhesion of the filaments to a greater or less extent, while the anthers remain free; thus, all the filaments of the Androecium may unite, forming a tube round the pistil (fig. 307 *e*), or

a central bundle when the pistil is abortive (fig. 314, 1), the stamens becoming *monadelphous* (μόνος, one, and ἀδελφὸς, brother), as occurs in Geranium (fig. 307), Malva, Hibiscus, and Jatropha Curcas (fig. 314, 1); or they may unite so as to form two bundles, the stamens being *diadelphous*, (δὶς, twice), as in Polygala, Fumaria, and Pea; in this case the bundles may be equal or unequal. It frequently happens, especially in Papilionaceous flowers, that out of ten stamens, nine are united by their filaments, while one (the posterior one) is free. When filaments form three or more bundles, the stamens are *triadelphous* (τρεῖς, three), as in Hypericum ægyptiacum (fig. 315), or *polyadelphous* (πολὺς, many), as in Luhea paniculata (fig. 316, 1), or in Ricinus communis (fig. 317, 1). The union of the filaments takes place sometimes at the base only, as in Tamarix gallica (fig. 311); at other times it extends throughout their whole length, so that the bundles assume a columnar form. In certain cases, the cohesion extends to near the apex, forming what Mirbel calls an *androphore* (ἀνὴρ, male or stamen, and φορέω, I bear,), or a column which divides into terminal branches, each bearing an anther (fig. 315, *f e*). Occasionally some filaments are united higher up than others, and thus a kind of compound branching



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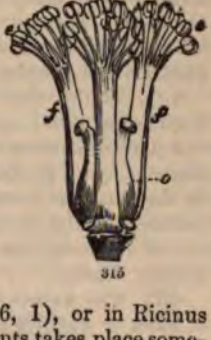

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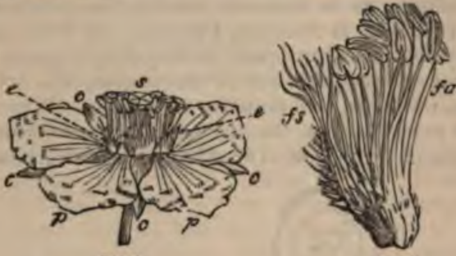
Fig. 314.—Male or staminiferous flower (1), and female or pistilliferous flower (2), of Jatropha Curcas. *c*, Calyx. *p*, Corolla. *e*, Stamens united by filaments occupying the centre in flower 1, in consequence of the suppression of the pistil. *p*, Pistil in flower 2, composed of ovary, *o*, with three bifid styles at its summit. *a*, Small glandular appendages alternating with the divisions of the corolla. Above each of the flowers is a diagram representing the order in which the different parts of the flower are arranged. In diagram 1 are represented five parts of the calyx, five of the corolla, two rows of stamens, five in each. In diagram 2, the staminal rows are abortive, and there are three carpels, forming the pistil, in the centre.

Fig. 315.—Triadelphous stamens of Hypericum ægyptiacum surrounding the pistil, *o*. *f f*, United filaments forming columns. *e e*, Anthers, free. The outer envelope of the flower has been removed, the essential organs alone being left.

is produced (fig. 317, 2). In Pancratium, the filaments are united by a membrane, which may be considered as corresponding to the crown of Narcissus.



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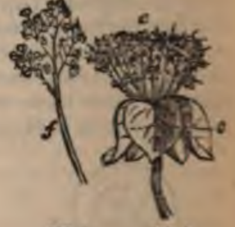


317, 2 317, 1

400. Filaments sometimes are united with the pistil, forming a *columna* or column, as in Stylidium, Asclepiadaceæ, Rafflesia, and Orchidaceæ. The column is called *gynostemium* (γυνή, pistil, and στήμων, stamen), and the flowers are denominated *gynandrous* (γυνή, pistil, and ἀνηρ, male or stamen.)

401. In the case of certain Achlamydeous (¶ 351) flowers, as Euphorbia, with only one stamen developed, there is the appearance of a jointed filament bearing one anther. This, however, is not a true filament, but a peduncle with a single stamen attached to it, as proved by the fact, that in some species of Euphorbia one or more verticils are produced at the joint. Thus the so-called anther is in reality a single flower supported on a stalk, all the parts being abortive, except a solitary stamen.

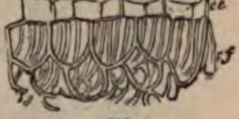
402. **The Anther** corresponds to the blade of the leaf, and consist of lobes or cavities containing minute powdery matter, called *pollen* which, when mature, is discharged by a fissure or opening of some sort. The anther-lobes may be considered as formed by the two halve of the lamina, their back corresponding to the under surface, and thei face to the upper surface, united by the midrib, the pollen bein cellular tissue, and the fissure of the anther taking place at the margi which, however, is often turned towards the face. In this view, th two cavities which are found to exist in each lobe, may correspon with the upper and under layer of cells, separated by a septu equivalent to the fibro-vascular layer of the leaf. Others view th

Fig. 316.—1. Flower of Luhea paniculata. *c c c c*, Segments of calyx. *p p*, Petals. *e e*, St mens grouped in bundles, which alternate with the petals. *s*, Stigma, composed of five pa indicating the union of five carpels. 2. One of the staminal bundles magnified, showing all t filaments united into a single mass at the base, but separating superiorly. *f a*, The larger ternal filaments, each ending in an anther. *f s*, The shorter outer ones, sterile and abortive.

Fig. 317.—1. Male flower of Ricinus communis, or Castor oil plant, consisting of a calyx, composed of five reflexed sepals, and of stamens, *s*, united by their filaments so as to form bundles, thus being polyadelphous. 2. One of the staminal bundles, *f*, branching above, so as leave the anthers free and separate.

anther as formed by each half of the lamina being folded upon itself, so that the outer surface of both face and back corresponds to the lower side of the leaf, and the septum dividing each cavity into two is formed by the upper surfaces of the folded half united.

403. There is a double covering of the anther—the outer, or *exothecium* (ἔξω, outwards,and θηκίον, a covering), resembles the epidermis, and often presents stomata and projections of different kinds (fig. 318 *c e*); the inner, or *endothecium* (ἔνδον, within), is formed by a layer or layers of fibro-cellular tissue (fig. 318 *c f*), the cells of which have a spiral (fig. 23), annular (fig. 24), or reticulated (fig. 25) fibre in their interior. This internal lining varies in thickness, generally becoming thinner towards the part where the anther opens, and there disappears entirely. The membrane of the cells is frequently absorbed, so that when the anther attains maturity the fibres are alone left, and these by their elasticity assist in discharging the pollen.



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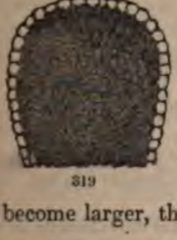
404. The anther is developed before the filament, and is always sessile in the first instance. In many examples it continues permanently so. It appears in the form of a small cellular projection, containing a mass of mucilaginous cells (fig. 319). In the progress of growth, certain grooves and markings appear on its surface, and its interior becomes hollowed out into two marked cavities, containing a mucilaginous matter (figs. 320, 321). In these cavities cells make their appearance—the outer small (figs. 320, 321, *c p*), forming ultimately the endothecium (fig. 318 *c f*); the interior layer forming cells in which the pollen is produced (figs. 320, 321, *u p*). As the cavities become larger, the layer of cells (figs 320, 321, *c i*), between



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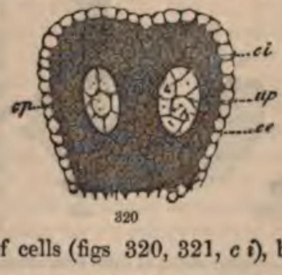

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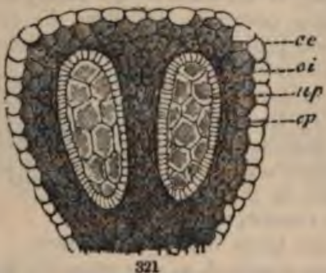
Fig. 318.—Transverse section of a portion of the covering of the anther of Cobæa scandens at the period of dehiscence. *c e*, Exothecium, or external layer, consisting of epidermal cells. *c f*, Endothecium, or inner layer, composed of spiral cells or inenchyma.

Fig. 319.—Transverse section of an anther of Cucurbita Pepo, or Gourd, taken from a bud about two millimetres, or 1-12th of an English inch, in length.

Fig. 320.—Similar horizontal section from a bud in a more advanced state. *c e*, Outer layer of cellules (*Exothecium*) forming the epidermis. *c i*, Intermediate layer of cellules in several layers, most of which are ultimately absorbed. *c p*, Internal layer of cells (*Endothecium*). *u p*, Anther-cavities filled with large cells, which constitute the first state of the pollen-utricles.

the endothecium, *c p*, and exothecium, *c e*, is gradually absorbed more or less completely, forming at first septa in the cavities; and ultimately the anther assumes its mature form, consisting of two lobes with their membranous coverings (fig. 322, *l*).



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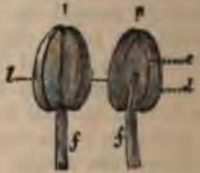

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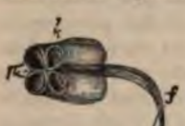
405. In the young state there are usually four cavities produced, two for each anther-lobe, separated by the *connective*, and each divided by the septum, which sometimes remains permanently complete, and thus forms a *quadrilocular* (*quatuor*, four, and *loculus*, a pouch or box), or *tetrathecal* (τέτρας, four, and θήκη, a sac) anther. The four cavities are sometimes placed in apposition, as in Poranthera (fig. 323) and Tetratheca juncea (fig. 324), and at other times two are placed above and two below, as in Persea gratissima (fig. 325 *l l*). In general, however, only two cavities remain in the anther, in consequence of the more or less complete removal of the septum, in which case the anther is said to be *bilocular* (*bis*, twice), or *dithecal* (δὶς, twice), as seen in figs. 322, 326. Sometimes the anther has a single cavity, and becomes *unilocular* (*unus*, one), or



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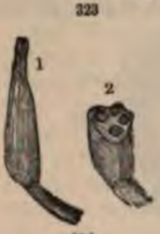

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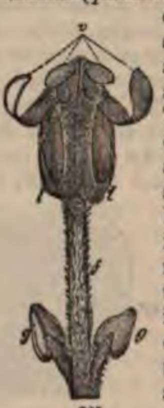

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Fig. 321.—Similar section in a still more advanced state. The letters have the same meaning as in the last figure.

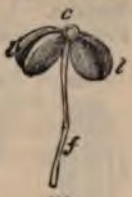
Fig. 322.—Anther of the Almond-tree. ', Seen in front. ", Seen behind. *f f*, Filament attached to the connective, *c*, by a point. *l l*, Anther-lobes containing pollen.

Fig. 323.—Quadrilocular anther, *l*, of Poranthera, attached to the filament, *f*, and opening at the summit by four pores, *p*.

Fig. 324.—Quadrilocular anther of Tetratheca juncea. 1. The anther entire, with its four loculaments ending in one opening. 2. Anther cut transversely, showing the four loculaments.

Fig. 325.—Anther of Persea gratissima, composed of four cavities or loculaments, *l l*, united in pairs, one above the other, and opening each by a valve, *v*. At the base of the filament, *f*, are two glands, *g g*, which seem to be abortive stamens.

monothecal (μόνος, one), either by the disappearance of the partition between the two lobes, or by the abortion of one of its lobes, as in Styphelia læta (fig. 327), and Althæa officinalis (fig. 328). Occasionally, there are numerous cavities in the anther, as in Viscum and Rafflesia. The number of loculi or cavities is only seen when the anther opens.



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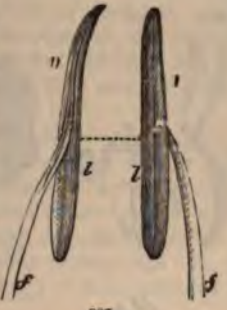

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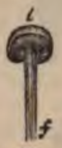

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406. The form of the anther-lobes varies. They are generally of a more or less oval or elliptical form (figs. 322, 329 *l*). Sometimes they are globular, as in Mercurialis annua (fig. 326); at other times linear or clavate (fig. 330), curved (fig. 331), flexuose, sinuose, or *anfractuose* (*anfractus*, winding). as in Bryony and Gourd (fig. 332). The lobes of the anther are sometimes in contact throughout their whole length (fig. 329), at other times they are separate (figs. 326, 333). In the former case their extremities may be rounded, forming a cordate anther (fig. 322), or the apex may be acute (figs. 312, 313); in the latter case the lobes may divide at the base only, and end in a sagittate or arrow-like manner (fig. 334 *l*); or at the apex, so as to be *bifurcate* or forked (fig. 335 *p*); or *quadrifurcate*, doubly forked (fig. 336 *l*); or at both base and apex, so as to be forked at each extremity, as in Grasses (fig. 337). The cavities of the anther are occasionally elongated so as to end in points (fig. 336 *l*). Sometimes the lower part of the antherine cavities is obliterated, and they degenerate into flattened appendages (fig. 338 *a*). It happens at times that the surface of the anther presents excrescences in the form of warts, awl-shaped pointed bodies (fig. 335 *a*), or crests (fig. 339 *a*).

407. That part of the anther to which the filament is attached, and which is generally towards the petals, is the *back*, the opposite being the *face*. The division between the lobes is marked on the face of the anther by a groove or *furrow*, and there is usually on the face, a *suture*, indicating the line where the membranous coverings open to discharge the pollen. The suture is often towards one side in consequence of the valves being unequal.

408. The anther-lobes are united either by a direct prolongation of

Fig. 326.—Pendulous anther lobes, *l l*, of Mercurialis annua, supported on the filament, *f*, and united by the connective, *c*.

Fig. 327.—Unilocular or monothecal anther of Styphelia læta, one of the Epacridaceæ, seen in front, ′, and behind, ″. *f*, Filament. *l*, Anther.

Fig. 328.—Unilocular anther of Althæa officinalis, or Marsh mallow. One of the lobes of the anther, *l*, abortive. *f*, Filament.

the filament, or more generally by a body called the *connective*, consisting of a mass of cellular tissue different from that contained in the filament. In this tissue the spiral vessels of the latter terminate. From the connective a partition or *septum* extends across each antherine loculus, dividing it either partially or completely. The septum sometimes reaches the suture. When the filament is continuous with the connective, and is prolonged so that the anther-lobes appear to be united to it throughout their whole length, and lie in apposition and

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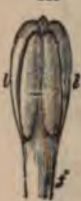

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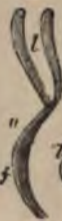

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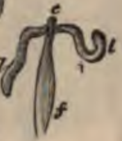

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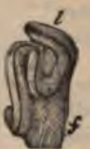

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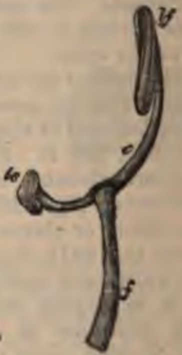

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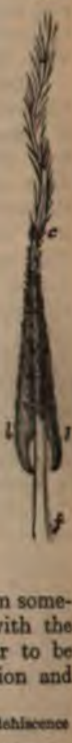

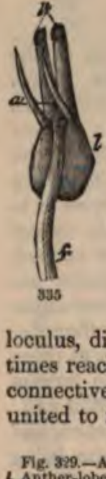

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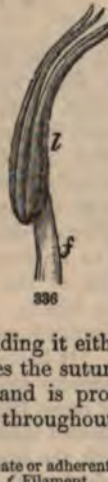

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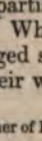

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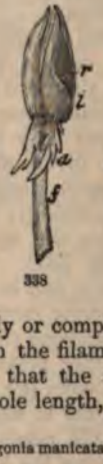

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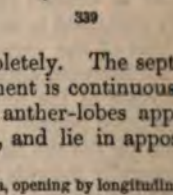

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Fig. 329.—Adnate or adherent anther of Begonia manicata, opening by longitudinal dehiscence *l*, Anther-lobes. *f*, Filament.

Fig. 330.—Forked or bifurcate anther, *l*, of Acalypha alopecuroidea, in the expanded flower.

Fig. 331.—Same anther in the bud, exhibiting a curved form.

Fig. 332.—Sinuous anther, *l*, of Bryonia dioica. *f*, Filament.

Fig. 333.—Anther of Salvia officinalis. *l f*, Fertile lobe full of pollen. *l s*, Barren lobe without pollen. *c*, Distractile connective.

Fig. 334.—Anther of Nerium Oleander, with its lobes, *l l*, sagittate at the base, and ending at the apex in a long feathery prolongation.

Fig. 335.—Anther, *l*, of Vaccinium uliginosum. *l*, Lobes ending in two pointed extremities which open by pores. *a*, Appendages to the lobes.

Fig. 336.—Quadrifurcate anther of Gaultheria procumbens. *l*, Lobes ending in four points.

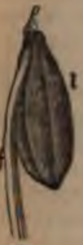
Fig. 337.—Versatile anther of Poa compressa. *f*, Filament. *l*, Lobes separating at each end.

Fig. 338.—Anther, *l*, of Erica cinerea. *f*, Filament. *r*, Lobes split partially downwards. *a*, Scale-like prolongations at the base.

Fig. 339.—Anther of Pterandra pyroidea. 1. Entire anther, seen laterally. 2. Lower half after having been cut transversely. *a a a*, Antherine appendages. *l l*, Anther-lobes. *c c*, Connective.

on either side of it, the anther is said to be *adnate* or *adherent* (fig. 329); when the filament ends at the base of the anther, then the latter is *innate* or *erect*. In these cases the anther is to a greater or less degree fixed. When, however, the attachment is very narrow, and an articulation exists, the anthers are then moveable, and easily turned by the wind. This is well seen in what are called *versatile* (*verto*, I turn) anthers, as in Tritonia, Grasses, &c. (figs. 260, 337), where the filament is attached only to the middle of the connective; and it may occur also in cases where it is attached to the apex, as in pendulous anthers (fig. 340).

409. The connective may unite the anther-lobes completely, or only partially. It is sometimes very short, and is reduced to a mere point, (fig. 326), so that the lobes are separate or free. At other times it is prolonged upwards beyond the lobes in the form of a point, as in Acalypha (fig. 331 *c*); or of a feathery awn, as in Nerium Oleander (fig. 334); or of a conical or tongue-like process (figs 341, 342 *c*); or of a membranous expansion (fig. 343 *c*); or it is extended backwards and downwards, in the form of a spur, as in fig. 343 *a*; or downwards, as in the case of the flaky appendage in Ticorea febrifuga. In Salvia officinalis (fig. 333), the connective is attached to the filament in a horizontal manner, so as to separate the two anther-lobes, and then it is called *distractile* (*dis*, separate, and *traho*, I draw). In Stachys, the connective is expanded laterally, so as to unite the bases of the antherine lobes, and bring them into a horizontal line.



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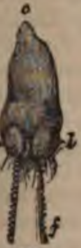

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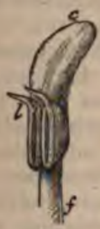

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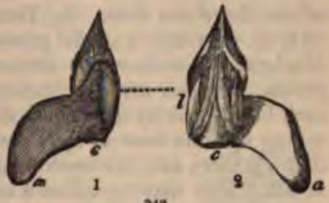

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410. The opening of the anthers to discharge their contents is denominated *dehiscence* (*dehisco*, I open). This takes place either by

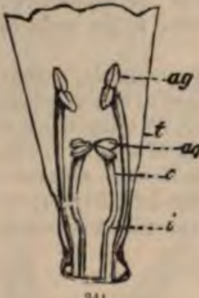
Fig. 340.—Pendulous anther, *l*, of Pyrola rotundifolia. The anther is suspended from the summit of the filament, *f*, and opens at its apex by two pores, *p*.

Fig. 341.—Anther of Humiria balsamifera. *l l*, Anther lobes. *f*, Filament, ciliated or fringed with glandular teeth. *c*, Conical appendage, which seems to be a prolongation of the connective.

Fig. 342.—Anther of Byrsonima bicorniculata. *f*, Filament. *l*, Anther-lobes. The empty lobes at the summit are detached in the form of two small horn-like projections *c*, A linguiform or tongue-like appendage prolonged from the connective.

Fig. 343.—Sessile anther of Viola odorata, or sweet violet. 1. Seen in front. 2. Seen behind. *l*, Anther-lobes. *a*, Spur-like appendage from the connective. *c*, Membranous expansion at the apex of anther-lobes.

clefts, by hinges, or by pores. When the anther-lobes are erect, the cleft takes place lengthwise along the line of the suture, constituting *longitudinal dehiscence* (figs. 322, 329, 342). At other times, the slit takes place in a horizontal manner, from the connective to the side, as in Alchemilla arvensis, and in Lemna, where the dehiscence is *transverse*. When the anther-lobes are rendered horizontal by the enlargement of the connective (figs. 328, 344 *a q*), then what is really longitudinal dehiscence may appear to be transverse. In other cases (fig. 344 *a g*), when the lobes are united at the base, the fissure in each of them may be continuous, and the two lobes may appear as one.



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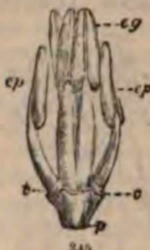
411. The cleft does not always proceed the whole length of the anther-lobe at once, but often for a time it extends only partially (figs. 343, 2, 338). In other instances the opening is confined to the base or apex, each loculament (*loculus*) opening by a single pore, as in Pyrola (fig. 340), Vaccinium (fig. 335), and Solanum, where there are two, and Poranthera (fig. 323), where there are four. In Tetratheca juncea, the four cavities (fig. 324, 2) open into a single pore at the apex (fig. 334, 1); and in the Mistleto, the anther has numerous pores for the discharge of the pollen. Another mode of dehiscence is called *hinged*. In the Barberry, each lobe opens by a valve on the outer side of the suture, separately rolling up from base to apex; while in some of the Laurel tribe (fig. 325 *v*), there are two such separating valves for each lobe, or four in all. This may be called a combination of transverse and hinged dehiscence. In some Guttiferæ, as Hebradendron cambogioides (the Gamboge plant), the anther opens by a lid separating from the apex, or by what is called *circumscissile* (*circum*, around, and *scindo*, I cut) dehiscence. In the last-mentioned dehiscence, the anther may be considered as formed of jointed leaves like those of the Orange, the blades of which separate at the joint.

412. The anthers open at various periods of flowering; sometimes in the bud, but more commonly when the pistil is fully developed, and the flower is expanded. They either open simultaneously or in succession. In the latter case, individual stamens may move towards the pistil and discharge their contents, as in Parnassia palustris, or the outer or the inner stamens may open first, following thus a centripetal or centrifugal order. The anthers are called *introrse* (*introrsum*, inwardly), or *anticæ* (*anticus*, the fore part), when they open on the

Fig. 344.—Corolla of Digitalis purpurea, cut in order to show the didynamous stamens (two long and two short) which are attached to it. *t*, Tube. *f*, Filaments which are united to the corolla at *i*, and run along its inner surface, having formed a marked adhesion. *a g*, Anthers of the long stamens. *a q*, Anthers of the short stamens.

the centre of the flower (fig. 345); they are *extrorse*
ardly), or *posticæ* (*posticus*, behind), when they open
:face; when they open on the sides,
ome grasses, they are called *laterally*
337). Sometimes anthers originally
ɩeir versatile nature, become extrorse,
n-flower and Oxalis. The attachment
either on the outer or inner side, and
he anther in the young state, assist in
direction of the dehiscence when the
pores, or are versatile.
al colour of anthers is yellow, but they
variety in this respect. They are red
ark purple in the Poppy and Tulip, orange in Esch-
The colour and appearance of the anthers often change
discharged their functions.



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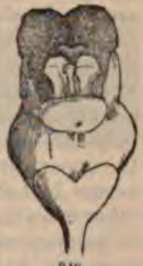
nes a flower consists of a single stamen, as already
l to Euphorbia (¶ 401). It is said also, that in the
the Fir, and in the Cycadaceæ, the stamens are to be
gle male flowers, supported on scales; being either a
ith bilocular anthers, as in Pinus, or unilocular, as in
l stamens united in an androphore, as in Taxus.
s occasionally become sterile by the degeneration or
it of the anthers, which, in consequence of containing
ential for fertilization; such stamens
e of *staminodia*, or rudimentary stamens.
(fig. 346), the fifth stamen, *s*, appears
scale; and in many Pentstemons it is
ment with hairs, or a shrivelled mem-
x. In other cases, as in double flowers,
e converted into petals. In Persea
325), two glands, *g*, are produced at the
ent in the form of stamens, the anthers
bortive. Sometimes only one of the
comes abortive. In many unilocular
-development of one lobe is indicated
roduction of a cellular mass resembling the connective.
re the connective is distractile, one of the lobes only is
(fig. 333 *l f*), containing pollen, the other (fig. 333
ly developed and sterile. In Canna, in place of one
etaloid appendage is produced.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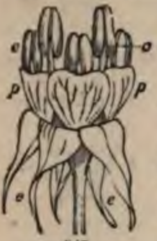
amous stamens (two long and two short) of Cheiranthus Cheiri. *p*, Top
icatrices left by the sepals of calyx which have been removed. *e g*, Two
e p, The short stamens. *t*, Torus or thalamus to which the stamens are

corolla of Scrophularia with a staminodium, *s*, or abortive stamen in the

416. It has been already stated, that the term nectary has been sometimes applied to modified stamens presenting abnormal appearances. Thus, in Parnassia palustris, the so-called nectaries are clusters of abnormal stamens (fig. 304 *n*), united by a membrane at the base, and ending in glandular bodies like anthers. Staminodia were also called nectaries (fig. 346 *s*). When treating of the disk, other modifications of stamens will be considered.



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417. The stamens, in place of being free and separate, may become united by their filaments (¶ 399). They may also unite by their anthers, and become *syngenesious* or *synantherous* (σὺν, together, and γένεσις, origin, or ἀνθηρά, anther). This union occurs in Composite flowers, and in Lobelia, Jasione, Viola, &c.

418. Stamens vary in length as regards the corolla. Some are enclosed within the tube of the flower, as in Cinchona, and are called *included* (figs. 287, 288, 344); others are *exserted*, or extend beyond the flower, as in Littorella, Plantago, and Exostemma. Sometimes the stamens in the early state of the flower project beyond the petals, and in the progress of growth become included, as in Geranium striatum (fig. 347). Stamens also vary in their relative lengths as respects each other. When there is more than one row or whorl of stamens in a flower, those on the outside are sometimes longest, as in Rosaceæ (fig. 308); at other times those in the interior, as in Luhea (fig. 316, 2 *f a*). When the stamens are in two rows, those opposite the petals are usually shorter than those which alternate with the petals.

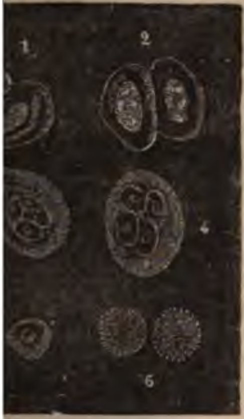
419. It sometimes happens that a single stamen is longer than all the rest. In some cases there exists a definite relation, as regards number, between the long and the short stamens. Thus, some flowers are *didynamous* (δὶς, twice, and δύναμις, power or superiority), having only four out of five stamens developed, and the two corresponding to the upper part of the flower longer than the two lateral ones. This occurs in Labiatæ and Scrophulariaceæ (figs. 344, 346). Again, in other cases there are six stamens, whereof four long ones are arranged in pairs opposite to each other, and alternate with two isolated short ones (fig. 345), and give rise to *tetradynamous* (τετρὰς, four, and δύναμις, power or superiority) flowers, as in Cruciferæ.

420. Stamens, as regards their direction, may be erect, turned inwards, outwards, or to one side. In the last-mentioned case they are called *declinate* (*declino*, I bend to one side), as in Amaryllis, Horse-chestnut, and Fraxinella.

421. **The Pollen.**—The pollen or powdery matter contained in the anther, consists of small cells developed in the interior of other cells.

Fig 347.—Bud of polypetalous corolla of Geranium striatum, exhibiting the stamens *e e*, at first longer than the petals, *p p*.

formed in the anther (fig. 321), are surrounded by a
r envelope, *c p*, and within this are produced large cells,
ing a granular mass (fig 348, 1), which divides into four
(fig. 348, 2), around which a membrane is developed,
riginal cell, or the parent *pollen-utricle*, becomes resolved
atic division (¶ 24) into four parts (fig. 348, 3), each of
a granule of pollen. The four cells continue to increase
distending the parent cell, and ultimately causing its
ad disappearance. They then assume the form of perfect
and either remain united in fours or multiples of four,
cacias, Periploca græca (fig. 349), and Inga anomala (fig.
rate into individual grains (fig. 348, 5), which by degrees
re pollen, (figs. 348, 6, 351, 352). In Acacia ringens,



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349 350

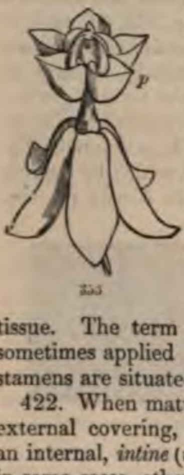
351 352

it pollen-grains united; in Acacia decipiens, twelve; and
aris, sixteen. Occasionally the membrane of the parent
not completely absorbed, and traces of it are detected in
tter, surrounding the pollen-grains, as in Onagrariaceæ.
ous plants, the pollen-grains are united into masses or

opment of the pollen of Viscum album, or the Mistleto. 1. Two pollen-cells
es filled with granular matter. 2. Four nuclei produced in this matter 3.
ur masses, each corresponding to a nucleus or a new utricle. 4. Pollenic or
ontaining three separate vesicles in its anterior. 5. Two of the latter, or the
ns, removed from the mother-cell or utricle. 6. The grains of pollen in their

a of Periploca græca, showing four grains agglutinated together.
a of Inga anomala. The grains united in multiples of four.
n-grain showing the extine covered with small punctuations.
n-grain with the extine covered with granulations.

pollinia, by means of viscid matter. In Asclepiadaceæ (fig. 353), the pollinia, *p* seem to have a special cellular covering, derived from a layer of reproductive pollen-cells, or from the endothecium. Pollinia in different plants vary from two to eight. Thus, there are usually two in Orchis, four in Cattleya, and eight in Lælia. The two pollinia in Orchis Morio, according to Amici, contain each about 200 secondary smaller masses. These small masses, when bruised, divide into grains which are united in fours. In Orchids, each of the pollen-masses has a prolongation or stalk, called a *caudicle* (*cauda*, a tail), which often adheres to a prolongation at the base of the anther, called *rostellum* (*rostellum*, a beak), by means of a viscid tenacious matter secreted by cells, and denominated *retinacula*, (*retinaculum*, a band or rein). Lindley considers the caudicle as derived from the stigma, and not from the pollinary tissue. The term *clinandrum* (κλίνη, a bed, and ἀνήρ, a stamen), is sometimes applied to the part of the column in Orchids, where the stamens are situated.



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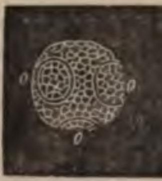
422. When mature, the pollen-grain is a cellular body having an external covering, *extine* (*exto*, I stand out, or on the outside), and an internal, *intine* (*intus*, within). Fritzsche states that he has detected, in some cases, other two coverings, which he calls *intextine* and *exintine*. They occur between the extine and intine, and are probably formed by foldings of these membranes. In some aquatics, as Zostera marina, Zannichellia pedunculata, Naias minor, &c., only one covering exists, and that is said to be the intine. The extine is a firm membrane, which defines the figure of the pollen-grain, and gives colour to it. It is either smooth or covered with numerous projections, granules, points,



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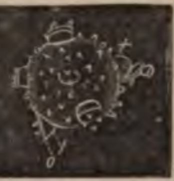

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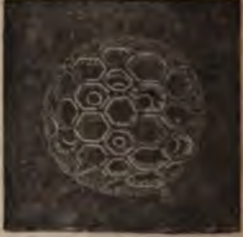

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Fig. 353.—Flower of Asclepias, showing the pollinia or pollen-masses, p, attached to the stigma.

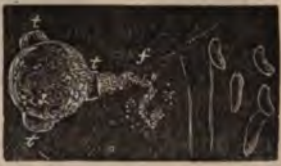
Fig. 354.—Pollen-grain of Passiflora before bursting. *o o o*, Opercula or lids formed by the extine, which open to allow the protrusion of the intine in the form of pollen-tubes.

Fig. 355.—Pollen-grain of Cucurbita Pepo, or Gourd, at the moment of its dehiscence or rupture. *o o*, Opercula or lids separated from the extine by the protrusion of the pollen-tubes, *t t*.

Fig. 356.—Pollen-grain of Ipomœa, with a reticulated extine.

rs, or crested reticulations (fig. 356). The colour is generally
d the surface is often covered with a viscid or oily matter.
is uniform in different kinds of pollen, thin and transparent,
sses great power of extension. It is said to be the first
ormed, the other being subsequently deposited while enclosed
ent cell.

'ithin these coverings a granular semifluid matter called
contained, along with some oily particles, and occasionally
he fovilla contains small sphe-
ules, sometimes the $\frac{1}{30000}$ of
diameter (fig. 357), and larger
or elongated corpuscles (fig.
ch are said to exhibit move-
ler the microscope similar to
in some Infusoria, and in
e, to be afterwards noticed.
ecular movements cease long
turation, except in Zostera marina and some other plants.
ollen-grains vary from $\frac{1}{300}$ to $\frac{1}{700}$ of an inch or less in dia-
heir forms are various. The most common form of grain is
(figs. 358, 359), more or less narrow at the extremities,
called its poles, in contradistinction to a line at *e*, equidistant
er extremity, and which is its equator. In figs. 359, 360,
he two surfaces of the pollen-grains of Allium fistulosum
olvulus tricolor are represented with their poles, *p*, their
and the longitudinal folds in their membrane; while at 3,



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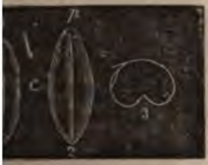

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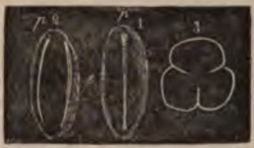
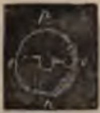


360

transverse sections at the equators, with a single fold in one
hree folds in the other. Pollen-grains are also of a spherical,
trigonal (fig. 362), or polyhedral figure (fig. 364). In the
, when there are markings on their surface, those at the

'ollen-grain of Amygdalus nana, the intine or internal membrane of which is pro-
ee pores under the form of as many ampullæ or sacs, *t t t*. One of these is open at
, and from it is discharged the fovilla, *f*, composed of variously-sized granules.
arge granules of fovilla of Hibiscus palustris.
'ollen of Allium fistulosum. *p*, Pole. *e*, Equator. 1. Pollen-grain seen on the face.
osite side or back. 3. Transverse section through its equatorial line.
'ollen of Convolvulus tricolor. The letters and numbers have the same signification

poles, *p*, sometimes differ from those at the equator, *e*. In Tradescantia virginica, the pollen is cylindrical, and becomes curved; it is polyhedral in Dipsaceæ and Compositæ; nearly triangular in Proteaceæ and Onagrariaceæ. The surface of the pollen-grain is either uniform and homogeneous, or it is marked by folds dipping in towards the centre, and formed by thinnings of the membrane. In Endogenous plants there is usually a single fold (fig. 359); in Exogens, often three (fig. 360). Two, four, six, and even twelve folds are also met with.



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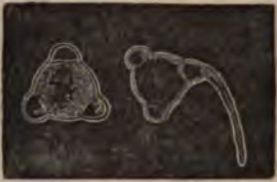

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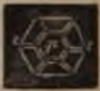

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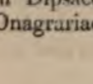
425. There are also pores or rounded portions of the membrane visible in the pollen-grain. These vary in number from one to fifty. In Endogens, as in Grasses, there is often only one (fig. 365); while in Exogens, they number from three upwards. When numerous, the pores are either scattered irregularly (fig. 366), or in a regular order, frequently forming a circle round the equatorial surface (fig. 361). Sometimes at the place where the pores exist, the outer membrane, in place of being thin and transparent, is separated in the form of a lid, thus becoming *operculate* (*operculum*, a lid), as in the Passion-flower (fig. 354) and Gourd (fig. 355). Grains of pollen have sometimes both folds and pores. There may be a single pore in each fold, either in the middle (fig. 367), or at the extremities; or folds with pores may alternate with others without pores; or finally, the pores and folds may be separate.



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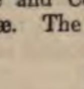

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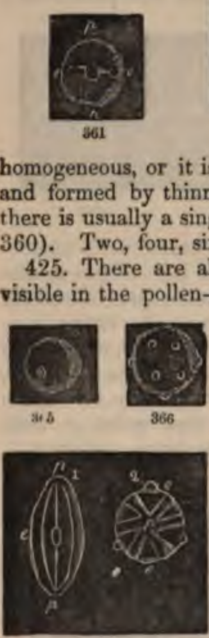

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Fig. 361.—Grain of pollen of Cannabis sativa, or common Hemp. *e*, Equator. *p p*, Poles.

Fig. 362.—Pollen-grain of Œnothera biennis entire, with three angles, where tubes are produced.

Fig. 363.—The same, with one of its angles giving origin to a pollen-tube, which is formed by the intine. When the tube protrudes, the extine is ruptured.

Fig. 364.—Polyhedral pollen-grain of Cichorium Intybus, or Chicory.

Fig. 365.—Pollen-grain of Dactylis glomerata, or Cocks-foot grass.

Fig. 366.—Pollen-grain of Fumaria capreolata.

Fig. 367.—Grain of pollen of Lythrum Salicaria, showing six folds, three of which are perforated by a pore in their middle, and three alternating with them have no pores. *p p*, Poles. *e e*, Equator. 1. The grain in a dry state. 2. The grain swollen in water, so as to take a globular *form* and display its folds. The intine or internal membrane begins to protrude through the pores.

426. The form of the pollen-grains is much altered by the application of moisture. Thus, in fig. 367, 1, the pollen grain of Lythrum Salicaria, when dry, has an ellipsoidal form, but when swollen by the application of water, it assumes a globular form (fig. 367, 2). This change of form is due to endosmose, and depends on the fovilla being denser than the water. If the grains are retained in water, the distension becomes so great as to rupture the extine irregularly if it is homogeneous, or to cause projections and final rupture at the folds or pores when they exist. The intine, from its distensibility, is not so liable to rupture, and it is often forced through the ruptured extine, or through the pores, in the form of small sac-like projections (figs. 367, 2, 362). This effect is produced more fully by adding a little nitric acid to the water. The internal membrane ultimately gives way, and allows the granular fovilla to escape (fig. 357 *f*). If the fluid is applied only to one side of the pollen-grain, as when the pollen is applied to the pistil, the distension goes on more slowly, and the intine is prolonged outwards like a hernia, and forms an elongated tube called a *pollen-tube* (fig. 363). This tube, at its base, is often covered by the ruptured extine, and probably also by some of the coverings mentioned by Fritzsche as intervening between it and the intine. It contains in its interior fovilla-granules, and its functions will be particularly noticed under fertilization. The number of pollen-tubes which may be produced depends on the number of pores. In some pollinia, the number of tubes which are found is enormous. Thus, Amici calculates that the two pollen-masses of Orchis Morio may give out 120,000 tubes.

427. **In Cryptogamic Plants** there are certain organs which are supposed by some to be equivalent to stamens. On that account they were denominated by Hedwig *antheridia*, by others *pollinaria*. They consist of closed sacs of different forms, rounded, ovate, oblong, clavate, flask-like, &c., developed in different parts of the plants, containing a number of corpuscles immersed in a mucilaginous fluid, which at a certain period of growth are discharged through an opening at the surface. Sometimes the antheridium is a simple cell, at other times it is composed of a number of cells, as in Hypnum triquetrum (fig. 368, 1). It either appears on the surface of the plant, or is concealed within its tissue. Antheridia are sometimes confined to particular parts of the plant, at other times they are more

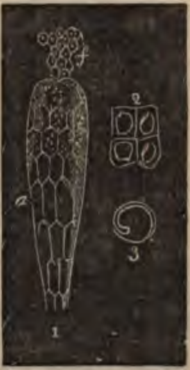

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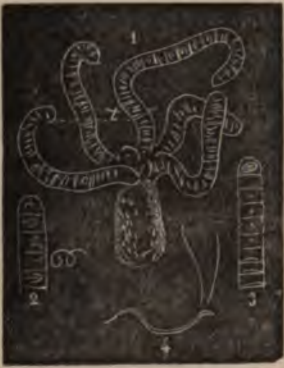
Fig. 368.—1. Antheridium or pollinarium, *a*, of a moss called Hypnum triquetrum, at the moment when its apex is rupturing to discharge the contents, *f*. 2. Four utricles of the contents containing each a phytozoon or moving corpuscle rolled up in a circular manner 3. Single phytozoon separated.

generally diffused. Their contents are small utricles or cellules, varying, like pollen-grains, in the different orders of cryptogamic plants, and enclosing in place of fovilla, peculiar bodies called *phytozoa* (φύτον, a plant, and ζῶον, an animal) (fig. 368, 2), which are often rolled up in a circular or spiral manner, as in Hepaticæ and Mosses (fig. 368, 3). These exhibit active movements at certain periods of their existence, and resemble in this respect animalcules. In Chara vulgaris (fig. 369), the antheridium or *globule*, as it is called, contains cells, 1, from which proceed numerous *septate* (*septum*, a division) tubes, *t*. In each of the divisions of these tubes, 2, there is a phytozoon which escapes in a spiral form, leaving the division empty, 3, and ultimately becomes unrolled, 4, exhibiting two vibratile cilia (*cilium*, an eyelash,) to which the movements are referred.



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428. **The Disk.**—The term *disk* is applied to whatever intervenes between the stamens and the pistil, and is one of those organs to which the name of *nectary* was applied by old authors. It presents great varieties of form, such as scales, glands, hairs, petaloid appendages, &c., and in the progress of growth it often contains saccharine matter, thus becoming truly nectariferous. The degeneration and transformation of the stamens frequently form the disk. It may consist of processes rising from the torus, alternating with the stamens, and thus representing an abortive whorl; or it may be opposite to the stamens, and then formed by chorization (¶ 383), as in Crassula rubens (fig. 258 *a*). In some flowers, as Jatropha Curcas, in which the stamens are not developed, their place is occupied by glandular bodies forming the disk (fig. 314, 2, *a*)

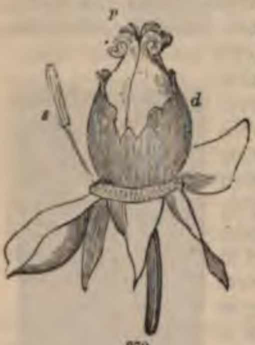

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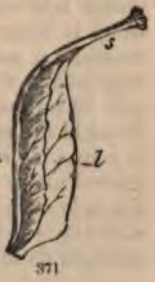
Fig. 369.—1. Portion of antheridium or globule of Chara vulgaris. Several septate or partitioned tubes, *t*, attached to a utricle or vesicle. A mass of similar utricles, forming the base of a large number of tubes, fills the cavity of the antheridium. 2. Extremity of one of these tubes, composed of several cellules, in each of which is a phytozoon. One of the phytozoa is represented half detached from the cellule. 3. Extremity of a tube from which the phytozoa have escaped, with the exception of the terminal cellule. 4. One of the phytozoa separated.

Fig. 370.—Disk, *d*, of Pæonia Moutan, or Tree Pæony, covering the ovary, and interposed between the whorl of stamens, *s*, and the pistil, *p*.

aceæ and Cruciferæ the disk consists of tooth-like scale
e of the stamens (fig. 345, *t*). The parts forming the disk
unite and form a glandular ring, as in the Orange; or a
amina covering the pistil, as in Pæonia Moutan (fig. 370, *d*),
lining of the calyx tube, as in the Rose (fig. 270 *c t*); or a
the top of the ovary, as in Umbelliferæ.

he Pistil.—The pistil occupies the centre or axis of the flower,
rounded by the stamens and floral envelopes, when these
t. It constitutes the innermost whorl, and is the female
he plant, which after flowering is changed into the fruit, and
e seeds. It sometimes receives the name of *gynœcium* (γυνὴ,
οἰκίον, habitation). It consists essentially of two parts, the
ermen, containing ovules or young seeds, and the *stigma*, a
creting body, which is either seated immediately on the ovary,
n called *sessile*, as in the Tulip and Poppy, (fig. 409), or is
n a stalk called the *style*, interposed between the ovary and
The style is not necessary for the perfection of the pistil.
it becomes blended with other parts, as with the filaments
hers in the column of Orchidaceæ.

ke the other organs, the pistil consists of one or more modi-
s, which in this instance are called *carpels* (καρπός, fruit).
gy of carpels to leaves may be deduced from their similarity
, and in venation, from the presence of stomata, hairs, and
om their resemblance to leaves in their nascent state; from
sional conversion into true leaves, as in Lathyrus latifolius;
the ovules corresponding in situation to the germs or buds
ome leaves, as those of Bryophyllum calycinum. When a
ists of a single carpel it is *simple*, a state usually depending
n-development of other carpels,; when it is composed of
rpels, more or less united, it is *compound*. In the first-
case, the terms carpel and pistil are
us. Each carpel has its own ovary, style
esent), and stigma, and is formed by a
, the upper surface of which is turned in-
ards the axis, and the lower outwards;
s margins are developed one or more buds
les. That this is the true nature of the pistil
en by examining the flower of the double-
Cherry. In it no fruit is produced, and the
ists usually of sessile leaves (fig. 371), the
ch being green and folded, with a narrow
on upwards, *s*, as if from the midrib, *n*, and



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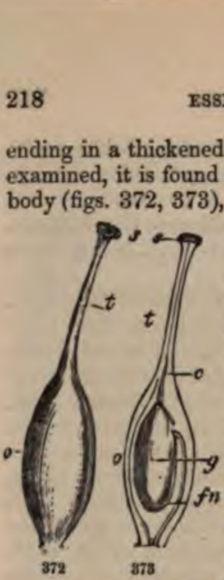
Carpellary leaf of the double-flowering Cherry. In this plant the pistil is composed
ne or more leaves folded inwards. *l*, Lamina or blade of the leaf or carpel. *s*, Pro-
he midrib, *n*, representing the style, and ending in a circular thickened portion
the stigma.

ending in a thickened portion. When the single-flowering Cl examined, it is found that, in place of folded leaves, there is body (figs. 372, 373), the lower part of which is enlarged, form ovary, *o*, and containing a single ov attached to its walls, with a bundle of vess entering it, a cylindrical prolongation, *t*, f the style, and a terminal expansion, *s*, the It will be seen that in this case two car leaves have become succulent and have together, so as to form a compound pist a single cavity containing one young see



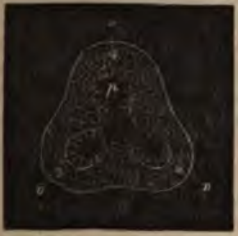
431. The *Ovary* then represents the l lamina of the leaf, and is composed of tissue with fibro-vascular bundles, and dermal covering. The cellular tissue, or chyma, often becomes much developed, be seen particularly when fleshy fruits a sidered. The outer epidermis correspond lower side of the leaf, exhibiting stomata, and sometimes hairs; th surface represents the upper side of the leaf, being usually very and pale, and forming a layer called sometimes *epithelium* (ἐπὶ, up θῆλυς, tender), which does not exhibit stomata. The vascular b correspond with the veins of the leaf, and consist of spiral, a and other vessels.

432. The *Style* has usually a cylindrical form, consists of cellul vascular tissue, and when carefully examined is found to be tra by a narrow canal (fig. 373 *c*), in which there are some loose p ing cells (figs. 374, 375), forming what is called the conducting A transverse section of the style of Crown Imperial (fig. 374), three vascular bundles, *v v v*, corresponding to three styles whi united into one, and *p*, loose cells in the canal of the style. canal is bounded by cellular tissue (fig. 375 *c c*), traversed by vessels, *v v*, and in its interior, besides the loose cells, *p p*, the especially at the period of fecundation, elongated tubes, *f f*, wh part fill up the canal. The name, *conducting tissue*, is given t found in the canal of the style, on account of the part which it in conveying the influence of the pollen to the ovules, as will plained under fertilization. Lindley has shown that in some ins the style seems to derive its origin from the placenta. The pr of the style is by no means essential to the perfection of the pist varies in its shape and position, being usually apicilar, but from

Fig. 372.—Pistil or carpel of the single-flowering Cherry in its normal state. *o*, O Style. *s*, Stigma.

Fig. 373.—The same cut vertically, to show the central cavity of the ovary, *o*, with th *g*, suspended from its wall at a point where a bundle of nourishing vessels, *f n*, termin Style traversed by a canal, *c*, which runs from the stigma, *s*, to the cavity of the ovary.

tion in the direction of the central axis, it occasionally seems to be lateral. Its form and appearance also varies; under ordinary circumstances it is rounded in shape, but occasionally becomes flattened. In the species of Clematis it is furnished with hairs; in Euphorbia it becomes forked.



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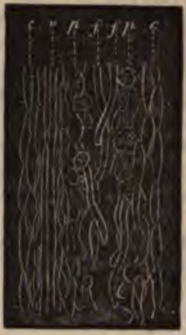

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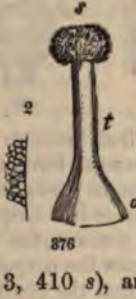
433. The *Stigma* is a continuation of the cellular tissue in the centre of the style, and it may be either terminal, when the canal opens at the top only (figs. 373 *s*, 376, 1), or lateral, when the splitting of the canal takes place on one side (fig. 377 *s*), or on both sides (fig. 378 *s s*). The stigma sometimes extends along the whole length of the style. In other instances the style is absent, when the stigma is said to be *sessile*. In Orchidaceous plants, it is placed on a part of the column called the *gynizus* (γυνή, pistil, and ἵζω, I sit). It is composed of cellular tissue more or less lax, and often having projecting cellules in the form of papillæ (fig. 376, 2), or of hairs (figs. 379, 3, 410 *s*), and at the period of



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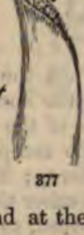

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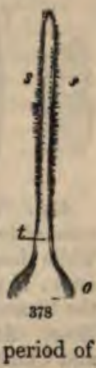

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Fig. 374.—Transverse section of the style of Fritillaria imperialis, or Crown Imperial. The style is composed of three united together. *v v v*, Three vascular bundles, each corresponding to one of the three styles. *p*, Papillæ or cellular bodies projecting into the cavity of the canal.

Fig. 375.—Structure of the canal in the centre of the style of a Campanula. *c c*, Cellular tissue forming its parietes traversed by tracheæ, *v*. *p p*, Variously formed cells, displaced as it were, and along with other elongated and filamentous ones, *f f*, obstructing the canal.

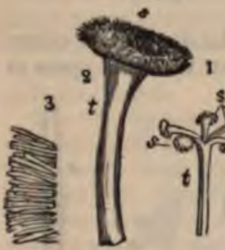
Fig. 376.—1. Stigma, *s*, of Daphne Laureola, terminating the style, *t*. *o*, Summit of the ovary. 2. A small portion of the surface of the stigma, much magnified to show its papillæ.

Fig. 377.—Unilateral stigma, *s*, of Asimina triloba. *t*, Style.

Fig. 378.—Bilateral stigma, *s s*, of Plantago saxatilis. *o*, Ovary. *t*, Style.

fertilization exuding a viscous fluid, which retains the grains of pollen, and causes the protrusion of tubes.

434. A pistil is usually formed by more than one carpel. The carpels may be arranged like leaves, either at the same or nearly the same height in a verticil (figs. 380, 381), or at different heights in a spiral cycle (fig 306 *c*). When they remain separate and distinct, thus showing at once the composition of the pistil, as in Caltha, Ranunculus, Hellebore, and Butomus (fig. 381), the term *apocarpus* (ἀπὸ, separate, and καρπὸς, fruit) is applied. Thus, in Crassula rubens (fig. 258), the pistil consists of five verticillate carpels, *o*, alternating with the stamens, *e*; and the same arrangement is seen in Xanthoxylon fraxineum (fig. 380). In the Tulip-tree (fig. 306), the separate carpels, *c c*, are numerous, and arranged in a spiral cycle, upon an elongated axis or receptacle. In the Raspberry, the carpels are on a conical receptacle; in the Strawberry, on a swollen succulent one; and in the Rose (fig. 270 *o o*), on a concave one, *r r*, covered by the tube of the calyx, *c t*.



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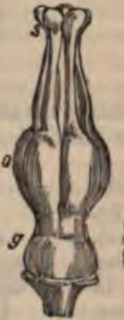

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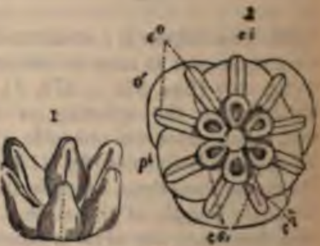

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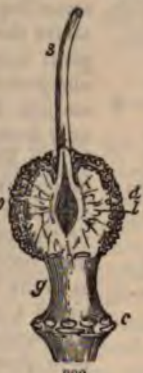
435. When the fruit consists of several rows of carpels on a flat receptacle, the innermost have their margins directed to the centre, while those of the outer rows are arranged on the back of the inner ones; if the receptacle is convex, the outer carpels are lowest, as in the Strawberry; if concave, the outer ones are uppermost, as in the Rose. At other times the carpels are united, as in the Pear, Arbutus, and Chickweed, so that the pistil becomes *syncarpous* (σὺν, together or

Fig. 379.—1. Summit of the style, *t*, of Hibiscus palustris, dividing into five branches, which are each terminated by a stigma, *s s*. 2. One of these branches highly magnified. 3. Portion of the surface of the stigma still more magnified to show its papillæ, which are elongated like hairs.

Fig. 380.—Pistil of Xanthoxylon fraxineum, consisting of five distinct carpels, supported on a gynophore, *g*. Each of the ovaries, *o*, bears a terminal style dilated at its extremity into a stigma, *s*. The five stigmata remain for a long time adherent by their sides.

Fig. 381.—1. Carpels of Butomus umbellatus, consisting of folded leaves arranged in different verticils. 2. Section of the same, showing the alternation of the parts of the flower. Three outer leaves of the perianth, *σ'*, alternating with three inner ones, *p i*, three rows of stamens, *e e* and *e i*, and the carpels, *c e* and *c i*.

united). In Dictamnus Fraxinella (fig. 382), five carpels unite to form a compound pistil. In Scilla italica (fig. 259), the three carpels form only one apparently; but on examination it will be found that the pistil consists of three carpels alternating with the three inner stamens. The union, however, is not always complete; it may take place by the ovaries alone, while the styles and stigmata remain free, the pistil being then *gamogastrous* (γάμος, union, and γαστήρ, ovary); and in this case, when the ovaries form apparently a single body, this organ receives the name of *compound* ovary; or the union may take place by the ovaries and styles, while the stigmata are disunited; or by the stigmata and the summit of the style only (fig. 380). Various intermediate states exist, such as partial union of the ovaries, as in the Rue, where they coalesce at their base; and partial union of the styles, as in Malvaceæ (fig. 383). The union is usually most complete at the base; but in Labiatæ the styles are united throughout their length, and in Apocynaceæ and Asclepiadaceæ, the stigmata only.



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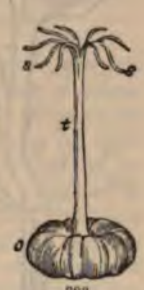

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436. When the union is incomplete, the number of the parts of a compound pistil may be determined by the number of styles and stigmata (fig. 383 *s*); when complete, the external venation, the grooves on the surface, and the internal divisions of the ovary, indicate the number. When the grooves between the carpels are deep, the ovary is denominated lobed, being one, two, three, four, or five-lobed, according to circumstances. In fig. 383, the nine carpels forming the ovary, *o*, are divided by grooves; and in fig. 384, a transverse section of the ovary of Fuchsia coccinea, shows the four carpels which form it. The changes which take place in the pistil by adhesion, degeneration, and abortion, are frequently so great as to obscure its composition, and to lead to anomalies in the

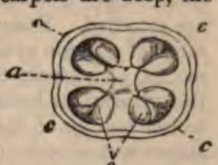

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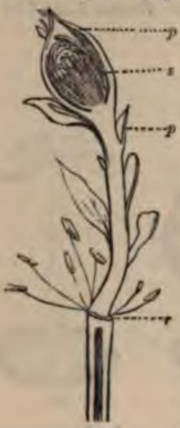
Fig. 382.—Portion of the pistil of Dictamnus Fraxinella. Two of the five carpels have been removed in order to show how the styles, *s*, produced on the inner side of the carpels, and at first distinct, approximate and become united into one. *o*, Ovaries, two of which in front show their dorsal surface, *d*, and their lateral surface, *l*. At the base of the gynophore, *g*, are seen the cicatrices, *c*, marking the insertion of the calyx, the petals, and the stamens.

Fig. 383.—Pistil of Malva Alcea. *o*, Nine ovaries, united so as to form one. *t*, Column formed by nine styles united to near their summit, where they diverge and separate. Each of the divisions of the style is terminated by a stigma, *s*.

Fig. 384.—Horizontal section of the four-celled (*quadrilocular* or *tetrathecal*) ovary of Fuchsia coccinea. *c c c c*, Wall of the ovary, which is formed by four carpellary leaves. *a*, Quadrangular axis to which the carpels are united. *o*, Ovules attached to the inner margin of the carpels.

alternation of parts. The pistil is more liable to changes of tl
than any other part of the flower.



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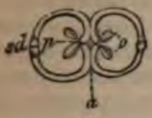
437. The carpels are usually sessile leav
sometimes they are petiolate, and then are e
above the external whorls. This elevation
pistil may in general, however, be traced
elongation of the axis itself, in such a way t
carpels, in place of being dispersed over i
only from its summit. A monstrosity often
in the Rose (fig 385), by which the axis
longed, and bears the carpels, *f*, in the f
alternate leaves. Thus, by the union of the p
of the carpels, or by lengthening of the a
pistil becomes *stipitate* (*stipes*, a trunk), or sup
as in the Passion-flower, on a stalk (figs. 380,
called a *gynophore* (γυνὴ, pistil, and φορέω, I
or *thecaphore* (θήκη, a case). Sometimes th
is produced beyond the ovaries, and the sty
come united to it, as in Geraniaceæ and U
liferæ. In this case the prolongation is ca
carpophore (καρπὸς, fruit, and φορέω, I bear).

438. The ovules are developed on the inner side of the carpel
the two edges of the carpellary leaves unite, and they are con
to it by vascular bundles which proceed from below upwards, tr
the carpel, and send a branch to each of the ovules. At the
place there is a development of cellular tissue in connection wi
conducting tissue of the style and with the stigma. By the un
these tissues is formed the *placenta*, or projection to which the
are attached. Some restrict the term placenta to the point of a
ment of a single ovule, and call the union of placentas, bearing s
ovules, *placentaries* or *pistillary cords*. The part of the carpel
the placenta is formed, is the *inner* or *ventral suture*, correspo
to the margin of the folded carpellary leaf, while the *outer* or
suture corresponds to the midrib of the carpellary leaf. The pl
is hence sometimes called *marginal*. The placenta is form
each margin of the carpel, and hence is essentially double. T
seen in cases where the margins of the carpel do not unite, but r
separate, and consequently two placentas are formed in place o
In fig. 386, the two carpels are folded, so that their margins mee
the placenta is apparently single; whereas in fig. 387 the marg
each carpel do not meet, and the placenta of each is double.
in fig. 388, the two carpels, after meeting in the centre or axis,

Fig. 385.—Section of monstrous Rose, as figured at section 324, the axis of which is p
beyond the flower, and the envelopes removed to show the abortive stamens, *r*. The ca
attached alternately along the axis in the form of leaves. *p*, Abortive floral envelopes.
an imperfect flower at the apex.

reflected outwards towards the dorsal suture, *s d*, and their margins separate slightly, each being placentary and bearing ovules, *o*.



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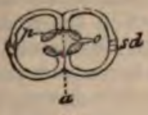

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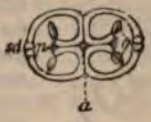

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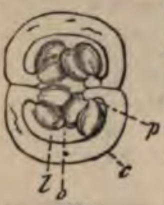
439. When the pistil is formed by one carpel, the inner margins nite in the axis, and form usually a common marginal placenta. his placenta may extend along the whole margin of the ovary as far s the base of the style, or it may be confined to the base or apex nly. When the pistil is composed of several separate carpels, or, in ther words, is apocarpous, there are generally separate placentas at ach of their margins. In a syncarpous pistil, on the other hand, the arpels are so united that the edges of each of the contiguous ones by heir union form a *septum* (*septum*, a fence or enclosure), or *dissepiment* *dissepio*, I separate), and the number of these septa consequently inicates the number of carpels in the compound pistil. It is obvious hen that each dissepiment is formed by a double wall or two laminæ; hat the presence of a septum implies the presence of more than one arpel; and that, when carpels are placed side by side, true dissepients must be vertical, and not horizontal.

440. When the dissepiments extend to the centre or axis, the vary is divided into cavities, *cells* or *loculaments* (*loculus*, a box), and may be *bilocular*, *trilocular*, *quadrilocular*, *quinquelocular*, or *multicular*, according as it is formed by two, three, four, five, or many arpels, each corresponding to a single cell or loculament (fig. 381, 2, 4, c i). In these cases the marginal placentas meet in the axis, and nite so as to form a single *central* one (fig. 386 *a*). Some call this lacentation *axile* (belonging to the *axis*), but this term is perhaps proerly restricted to cases where the placenta is an actual prolongation f the axis. The number of loculaments is equal to that of the disepiments. In fig. 384, there is shown a transverse section of the ovary f Fuchsia coccinea, *c c c c* being its parietes formed by the union of our carpellary leaves, *a* the axis united to the parietes by dissepiments, nd *o* the ovules attached to the placentas at the margin of each carpel. Vhen the carpels in a syncarpous pistil do not fold inwards completely o as to meet in the centre, but only partially, so that the dissepiments ppear as projections on the walls of the ovary, then the ovary is *nilocular* (fig. 387), and the placentas are *parietal* (*paries*, a wall).

Figs. 386, 387, 388.—Horizontal sections of ovaries, composed of two carpellary leaves, the edges which are folded so as to meet in the axis, *a*, in fig. 387; are reflected inwards into the loculaents after meeting in the axis in fig. 388; and do not reach the axis in fig. 387.

A horizontal section of the ovary of Erythræa Centaurium (fig. 389), exhibits a unilocular ovary with parietal placentas, *p*, formed at each of the margins of the carpels which do not meet in the centre. In these instances the placentas may be formed at the margin of the united contiguous leaves, so as to appear single, or the margins may not be united, each developing a placenta. From this it will be seen that dissepiments are opposite to placentas, formed by the union of the margins of two contiguous carpels, but alternate with those formed by the margins of the same carpel.



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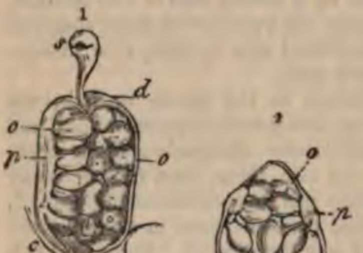
441. The carpellary leaves may fold inwards very slightly, or they may be applied in a valvate manner, merely touching at their margins, the placentas then being parietal, and appearing as lines or thickenings along the walls. In fig. 390, the pistil of Viola tricolor is represented, 1, cut vertically, and, 2, cut transversely, the ovules being attached to the walls of the ovary, and the placentas, *p*, being merely thickened portions of the walls. Cases occur, however, in which the placentas are not connected with the walls of the ovary, and form what is called a *free central placenta.* This is seen in many of the Caryophyllaceæ. Thus, in Cerastium hirsutum (figs. 391, 392), the ovary, *o*, is composed of five carpels, indicated by the styles, *s*, but there is only one loculament, the placenta, *p*, being free in the centre, and the ovules, *g*, attached to it.



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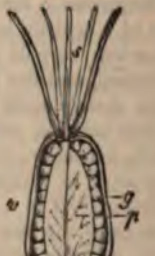

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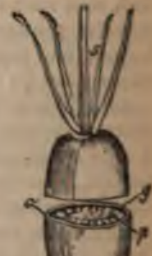

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Fig. 389.—Horizontal section of the ovary of Erythræa Centaurium. *c*, Wall or paries of the ovary or carpellary leaf. *p*, The edge on which the placenta is formed, bearing the ovules. *l*, Cell or loculament

Fig. 390.—Pistil of Viola tricolor, or Pansy, cut vertically to show the ovules, *o*, attached to the parietes. Two rows of ovules are seen, one in front, and the other in profile. *p*, A thickened line on the walls forming the placenta. *c*, Calyx. *d*, Ovary. 1. Hooded stigma terminating the short style. 2. Horizontal section of the same. *p*, Placenta. *o*, Ovules. *s*, Suture.

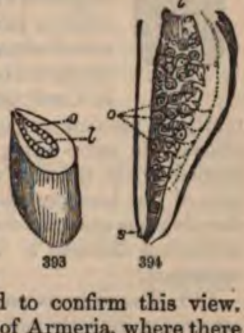
Fig. 391.—Pistil of Cerastium hirsutum cut vertically. *o*, Unilocular or monothecal ovary. *p*, Free central placenta. *g*, Ovules. *s*, Styles.

Fig. 392.—The same cut horizontally, and the halves separated so as to show the interior of the cavity of the ovary, *o*, with the free central placenta, *p*, covered with ovules, *g*

442. In Caryophyllaceæ, however, while the placenta is free in the centre, there are often traces found at the base of the ovary of the remains of septa, as if rupture had taken place; and, in rare instances, ovules are found on the margins. But examples occur of this kind of placentation, as in Primulaceæ, Myrsinaceæ, Santalaceæ, and Theophrasteæ, in which no vestiges of septa or marginal ovules can be perceived at any period of growth. Duchartre states that the free placenta of Primulaceæ is totally different from that of Caryophyllaceæ. It is always free, and rises in the centre of the ovary, and the part uncovered by ovules gradually extends into the style. It is not first continuous with the style, and then free; neither is it originally marginal, and then free; but it is, according to him, wholly throughout its *organogeny* (ὄργανον, organ, and γένεσις, production or development) separate and axile.

443. This placentation, therefore, has been accounted for in two ways, either by supposing that the placentas in the early state were formed on the margins of carpellary leaves, and that in the progress of development these leaves separated from them, leaving the placentas and ovules free in the centre; or by supposing that the placentas are not *marginal* but *axile* formations, produced by an elongation of the axis, the ovules being lateral buds, and the carpels verticillate leaves, united together around the axis. The latter view has been supported by many botanists, and is confirmed by the fact, that in some cases the placenta is actually prolonged beyond the carpels. The first of these views would apply well to Caryophyllaceæ, the second to Primulaceæ. In the latter case, the only way of explaining the appearance on the marginal hypothesis, will be by considering the placentas as formed from the carpels by a process of chorization (¶ 383), and united together in the centre.

444. Some indeed, as Schleiden and Endlicher, consider the axile view of placentation as applicable to all cases, the axis in some cases remaining free and independent, at other times sending prolongations along the margins of the carpellary leaves, and thus forming the marginal placentas. The occurrence of placentas over the whole inner surface of the carpels or of the dissepiments, as in Nymphæa and in Butomus umbellatus (figs. 393, 394); also, though very rarely, along the dorsal suture, as in Cabomba, or on lines within the margin, as in Orobanche, has been supposed to confirm this view. Schleiden argues in favour of it, from the case of Armeria, where there



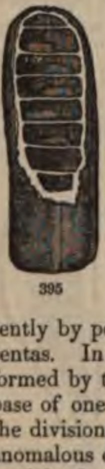
Figs. 393, 394.—One of the carpels of Butomus umbellatus, or flowering Rush, cut transversely in 393, and longitudinally in 394. *l*, Loculament or cavity of the carpel. *o*, Ovules. *s*, Stigmata.

are five carpels and a single ovule attached to a cord, which arises from the axis, and becomes curved at the apex so as to suspend the ovule; also, from cases, such as Taxus, where the ovule appears to be naked and terminates a branch.

445. This theory of placentation, however, cannot be easily applied to all cases; and Gray says that it is disproved in cases of monstrosity, in which the anther is changed into a carpel, or where one part of the anther is thus transformed and bears ovules, while the other, as well as the filament, remain unchanged. In the case of Luffa fœtida, the entangled fibres of the carpellary leaves, even in the young state, seem to be connected with perpendicular lines forming the placenta. Brongniart mentions a case where the marginal placenta was entire, while the axis was prolonged separately, and totally unconnected with the placenta; he also notices peculiar monstrosities, which seem to prove that, in some cases at least, marginal placentation must take place.

446. Upon the whole, then, it appears that marginal, or, as it is often called, carpellary placentation, generally prevails; that axile placentation explains easily cases such as Primulaceæ, while such instances as Caryophyllaceæ are explicable on either view.

447. Occasionally, divisions take place in ovaries which are not formed by the edges of contiguous carpels. These are called *spurious dissepiments*. They are often horizontal, and are then called *phragmata* (φρᾶγμα, a separation), as in Cathartocarpus Fistula (fig. 395), where they consist of transverse cellular prolongations from the walls of the ovary, only developed after fertilization, and therefore more properly noticed under fruit. At other times they are vertical, as in Datura, where the ovary, in place of being two-celled, is thus rendered four-celled; in Cruciferæ, where the prolongation of the placentas forms a *replum* (*replum*, leaf of a door) or partition; in Astragalus and Thespesia, where the dorsal suture is folded inwards; and in Diplophractum, where the inner margin of the carpels is reflexed (fig. 388). In Cucurbitaceæ, divisions are formed in the ovary, apparently by peculiar projections sent inwards from curved parietal placentas. In some cases, horizontal dissepiments are supposed to be formed by the union of carpels situated at different heights, so that the base of one becomes united to the apex of another. In such cases, the divisions are true dissepiments formed by carpellary leaves. The anomalous divisions in the ovary of the Pomegranate have been thus explained.



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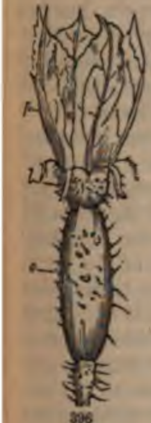
448. The ovary is usually of a more or less spherical or curved form, sometimes smooth and uniform on its surface, at other times hairy

Fig. 395.—Pistil of Cassia or Cathartocarpus Fistula, in an advanced state, cut longitudinally to show the spurious transverse dissepiments, or phragmata.

and grooved. The grooves, especially when deep, indicate the divisions between the carpels, and correspond to the dissepiments. The dorsal suture may be marked by a slight projection, or by a superficial groove.

449. The ovary is either free in the centre of the flower, or it is united to the surrounding parts, more especially to the calyx. The union may take place completely, so that the calyx is *adherent* throughout, and becomes *superior*, while the ovary is *inferior*, as in the Melon (fig. 396, *o* being the ovary, *l* the upper part of the adherent calyx); or it may take place partially, as in Saxifragaceæ (figs. 397, 398), where



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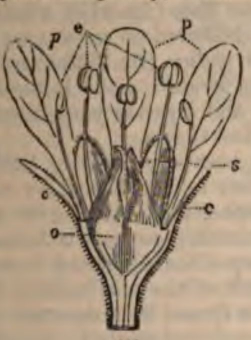

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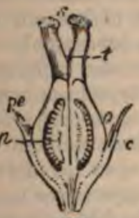

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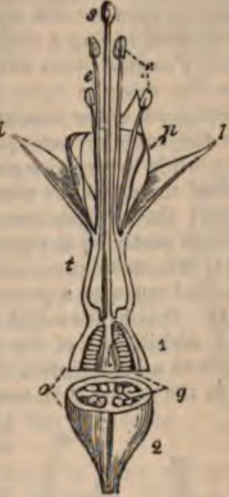

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Fig 396.—Flower of Cucumis Melo, or Melon. *o*, Inferior ovary covered by the adherent calyx. *l*, Limb of the calyx appearing above the ovary. *p*, Corolla.

Fig 397.—Flower of Saxifraga Geum, cut vertically to show the ovary, *o*, adherent for half its height to the calyx. *c*, The calyx, which is called half-superior. *p*, Petals. *e*, Stamens. *s*, Styles and stigmas.

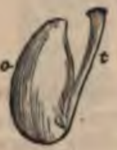
Fig. 398.—Pistil of Hoteia japonica, one of the Saxifragaceæ, cut vertically in order to show the interior of its two cavities or loculaments. It is a bilocular or dithecal ovary. *o*, Two ovaries consolidated into one, and adherent for half their height to the calyx, *c*. *t*, Styles. *s*, Stigmas. *p*, Placentas covered with ovules. *p e*, Base of the petals.

Fig. 399.—Flower of Fuchsia coccinea divided horizontally into two halves through the middle of the ovary, *o*. The lower half, 2, of the ovary has been left untouched, to show its four cavities or loculi, with the ovules attached to their internal angles. Fig. 384 shows the same section more highly magnified. The upper half, 1, has been cut vertically, to show the ovules, *g*, arranged in a row in each loculament. The calyx, incorporated with the ovary below, is prolonged above it in the form of a tube, *t*, and divides at its summit into four segments, *l l*. *p*, Petals inserted on the tube of the calyx at the place where it divides into segments. *e*, Stamens inserted also on the tube, alternately large and small. The style rising from the summit of the ovary, and terminated by an ovoid stigma, *s*.

the ovary, *o*, becomes *half-inferior*, the calyx being *half-superior*. These adhesions between the calyx and the ovary will be found to be of importance, as determining the *epigynous* and *perigynous* (ἐπί, upon or above, and περί, around, and γυνή, pistil) condition of the stamens. Cases of adhesion between the ovary and the calyx, as occur in the Apple, Pear, Gooseberry, and Fuchsia, (fig. 399), must not be confounded with cases such as the Rose (fig. 270), where the tube of the calyx becomes enlarged and hollowed so as to cover the carpels. In the former case a transverse section (fig. 399) shows one or several closed loculaments containing ovules; while in the latter, it exhibits one cavity open at the top, and separate carpels scattered over the surface, each having a style and stigma.

450. Peculiar views have been advocated by Schleiden, who considers the ovary in some cases as not formed by carpels, but by a hollowing out of the axis, at other times by these two modes combined. Thus the superior ovary, according to him, is formed of carpellary leaves, while the inferior ovary of the Apple and Pomegranate is composed of the expanded summit of the axis, bearing the carpels in its interior; that of Epilobium is formed from the stem alone, and that of Saxifrage partly by the peduncle and partly by carpels.

451. **The Style** proceeds from the summit of the carpel, and may be looked upon as a prolongation of it in an upward direction (fig. 372 *t*). It is hence called *apicilar* (*apex*, top). It consists not merely of the midrib, but of the vascular and cellular tissue of the carpel, along with a continuation of the placenta or conducting tissue, which ends in the stigma. In some cases, the carpellary leaf is folded from above downwards, in a hooded manner, so that its apex (as in reclinate vernation, fig. 205 *a*) approaches more or less to the base. When the folding is slight, the style becomes *lateral* (fig. 382); when to a greater extent, the style appears to arise from near the base, as in the Strawberry (fig. 400), or from the base, as in Chrysobalanus Icaco (fig. 401), when it is *basilar*. In all these cases the style still indicates the organic apex of the ovary, although it may not be the apparent apex.



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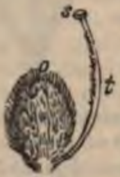

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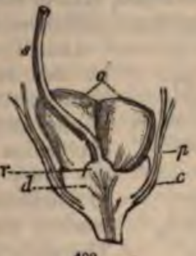
452. The carpel sometimes becomes imbedded in the torus or thalamus, so as to have a projection of the latter on one side; and then, if the style is basilar or lateral, it may adhere to this portion of the torus, and appear to arise from it. This is seen in Labiatæ (fig. 402), and Boraginaceæ (fig. 403), where the four carpels, *o*, are sunk in the

Fig. 400.—Carpel of Strawberry. *o*, Ovary. *t*, Style arising from near the base, and becoming basilar by the mode in which the ovary is developed; the style, however, still indicating the organic apex of the ovary.

Fig. 401.—Carpel of Chrysobalanus Icaco. *o*, Ovary. *t*, Basilar style. *s*, Stigma.

torus, *r*, in such a way that the common style, *s*, formed by the union of four basilar styles, seems to be actually a prolongation of the torus. When ovaries are thus attached round a central prolongation of the torus, continuous with a united columnar style, the arrangement is called a *gynobase* (γυνή, pistil, and βάσις, base). It is well developed in Ochnaceæ. In Geraniums there is a carpophore or prolongation of the torus in the form of a long beak, to which the styles are attached.



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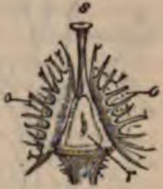

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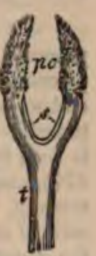
453. The form of the style is usually cylindrical, more or less filiform and simple; sometimes it is grooved on one side, at other times it is flat, thick, angular, compressed, and even petaloid, as in Iris and Canna. In Goodeniaceæ it ends in a cup-like expansion enclosing the stigma. It may be smooth and covered with glands and hairs. These hairs occasionally aid in scattering the pollen, and are called *collecting hairs*, as in Goldfussia or Ruellia. In Campanula they appear double and retractile. In Aster and other Compositæ (fig. 404), there are hairs produced on parts of the style, *p c*, prolonged beyond the stigma, *s*; these hairs, while the part is being developed, come into contact with the pollen and carry it up along with them. In Vicia and Lobelia, the hairs form often a tuft below the stigma.



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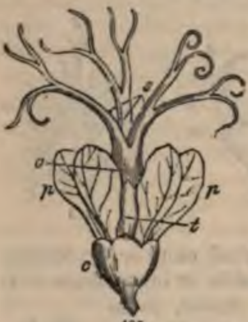
454. The styles of a syncarpous pistil may be either separate or united; when separate, they alternate with the septa. When united completely, it is usual to call the style *simple* (fig. 399); when the union is partial, then the style is said to be *bifid*, *trifid*, *multifid*, according as it is two-cleft, three-cleft, many-cleft; or, to speak more correctly, according to the mode and extent of the union of two, three, or many styles. The style is said to be *bipartite*, *tripartite*, or *multipartite*, when the union of two, three, or many styles only extends a short way above the apex of the ovary. The style from a single carpel, or from each carpel of a compound pistil, may also be divided. In

Fig. 402.—Pistil of Lamium album, shown by a vertical section of part of the flower. Two of the four ovaries have been removed to exhibit the connection of the style with the torus, *r*, by adhesion. *o*, The two remaining ovaries. *d*, Glandular disk placed below the pistil. *c*, Part of calyx. *p*, Corolla.

Fig. 403.—Pistil of Erithricium Jacquemontianum, with one of the ovaries removed in front, to show the manner in which the ovaries are inserted obliquely on a pyramidal torus, *r*, whence the style appears to arise, ending in a stigma, *s*.

Fig. 404.—Summit of the style, *t*, of an Aster, separating into two branches, *s*, each terminated by an inverted cone of collecting hairs, *p c*. The stigma, *s*, is seen below in the form of a band or line on the inner curvature of the branches.

fig. 314, 2, each division of the tricarpellary ovary of Jatropha Curcas has a *bifurcate* or forked style, *s*, and in fig. 405, the ovary of Emblica officinalis has three styles, each of which is divided twice in a bifurcate manner, exhibiting thus a dichotomous division.



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455. The length of the style is determined by the relation which ought to subsist between the position of the stigma and that of the anthers, so as to allow the proper application of the pollen. In some cases the ovary passes directly into the style, as in Digitalis, in other instances there is a marked transition from one to the other. The style may remain *persistent*, or it may fall off after fertilization is accomplished, and thus be *deciduous*.

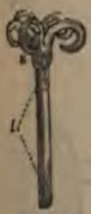
456. **The Stigma** is the termination of the conducting tissue of the style, and is usually in direct communication with the placenta. It may, therefore, in most instances, be considered as the placentiferous portion of the carpel prolonged upwards. In Armeria, and some other plants, this connection with the placenta cannot be traced. Its position may be either terminal or lateral. The latter is seen in some cases, as Asimina triloba, where it is *unilateral* (fig. 377), and in Plantago saxatilis (fig. 378), where it is *bilateral*. Occasionally, as in Tasmannia, it is prolonged along the whole inner surface of the style. In Iris, it is situated on a cleft on the back of the petaloid divisions of the style. Some stigmata, as those of the Mimulus, present sensitive flattened laminæ which close when touched. The stigma consists of loose cellular tissue, and secretes a viscid matter which detains the pollen, and causes it to protrude tubes. This secreting portion is, strictly speaking, the true stigma, but the name is generally applied to all the divisions of the style on which the stigmatic apparatus is situated, as in Labiatæ. The stigma alternates with the dissepiments of a syncarpous pistil, or corresponds with the cells; but in some cases, it would appear that half the stigma of one carpel unites with half that of the contiguous carpel, and thus the stigma is opposite the dissepiments, or alternates with the cells. This appears to be the case in the Poppy, where the stigma of a single carpel is two-lobed, and the lobes are opposite the septa.

457. If the stigma is viewed as essentially a prolongation of the placenta, then there is no necessary alternation between it and the placenta, both being formed by the margins of carpellary leaves, which

FIG. 405.—Female flower of Emblica officinalis, one of the Euphorbiaceæ. *c*, Calyx. *p p*, Petals. *t*, Membranous tube surrounding the ovary. *o*, Ovary, crowned by three styles, *s*, each being twice bifurcate.

in the one case are ovuliferous, in the other stigmatiferous. There is often a notch in one side of a stigma (as in some Rosaceæ), indicating apparently that it is a double organ like the placenta. To the division of a compound stigma the terms *bifid*, *trifid*, &c., are applied, according to the number of the divisions. Thus, in Labiatæ (fig. 299), and in Compositæ (figs. 301, 404 *s*), the stigma is bifid; in Polemonium, trifid. When the divisions are large, they are called *lobes*, and when flattened like bands, *lamellæ*; so that stigmas may be *bilobate*, *trilobate*, *bilamellar*, *trilamellar*, &c.

458. It has already been stated that the divisions of the stigma mark the number of carpels which are united together. Thus, in Campanula (fig. 405 *bis*), the quinquefid or five-cleft stigma indicates five carpels, the stigmata of which are separate, although the other parts are united. In Bignoniaceæ (fig. 406), as well as in Scrophulariaceæ and Acanthaceæ, the two-lobed or bilamellar stigma indicates a bilocular ovary. Sometimes, however, as in the case of the styles, the stigma of a single carpel may divide. It is probable that in many instances, what is called bifurcation of the style is only the division of the stigma. In Gramineæ and Compositæ (figs. 301, 404), there is a bifid stigma and only one cavity in the ovary. This, however, may be probably traced to subsequent abortion of the ovary of one of the carpels. The stigma presents various forms. It may be globular, as in Mirabilis Jalapa (figs. 376, 407); orbicular, as in Arbutus Andrachne (fig. 408); umbrella-like, as in Sarracenia, where, however, the proper stigmatic surface is below the points of the large expansion of the apex of the style; ovoid, as in Fuchsia (fig. 399); hemispherical; polyhedral; radiating, as in the Poppy (fig. 409), where the true stigmatic rays are attached to a sort of *peltate* or shield-like body, which may repre-



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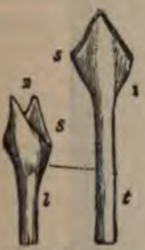

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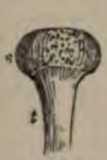

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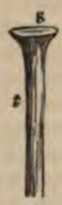

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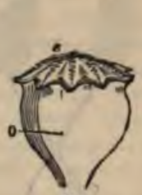

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Fig. 405, *bis*.—Stigmas, *s*, of Campanula rotundifolia. *l*, Style.

Fig. 406.—Bilamellar stigmas of Bignonia pandorea. The two lamellæ are applied naturally against each other in 1, while in 2 they are artificially separated.

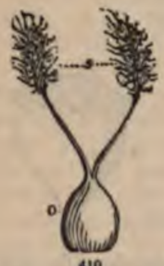
Fig. 407.—Globular stigma of Mirabilis Jalapa. *t*, Style. *s*, Stigma.

Fig. 408.—Circular stigma, *s*, and *t*, style of Arbutus Andrachne.

Fig. 409.—Pistil of Papaver somniferum, or opium Poppy. *o*, Ovary. *s*, Radiating stigmas on its summit.

sent depressed or flattened styles. The lobes of which a stigma consists may be flat or pointed, as in Mimulus and Bignonia (fig. 406); or fleshy and blunt, smooth, granular, feathery, as in many Grasses (fig. 410). In Orchidaceæ, the stigma is placed on the column formed by the union of the styles and filaments. The situation where it occurs has been called *gynizus* (¶ 433). In Asclepiadaceæ the stigmas are united to the face of the anthers, and along with them form a solid mass (fig. 353).

459. **In Cryptogamic Plants** there exist organs called *pistillidia*, which have been supposed to perform the function of pistils. They consist of hollow cavities, like ovaries, to which the names of *sporangia* (σπορὰ, a spore or seed, and ἄγγος, a vessel), and *thecæ* (θήκη, a sac), have been given, containing bodies called *spores*, equivalent to ovules. These spores being capable of germination, and being devoid of cotyledons, have been termed leafless phytons. The sporangia, or spore-cases, are sometimes immersed in the substance of the plant, as in Riccia glauca (fig. 411, 1); at other times they are supported on stalks, or *setæ* (*seta*, a bristle), as in Mosses. In Marchantia polymorpha, they consist of distinct and separate expansions, having a bottle-like form (fig. 412), the lower part, *o*, being enlarged, contain-



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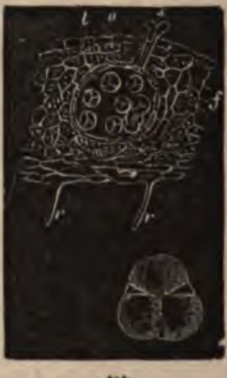

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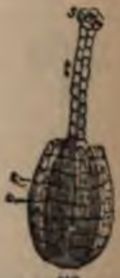

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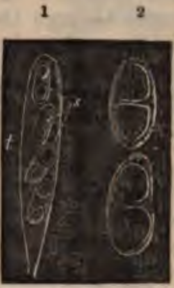
Fig. 410.—Pistil of Cynodon Dactylon, a Grass. *o*, Ovary. *s*, Feathery Stigmas.

Fig. 411.—1. Perpendicular section of the frond, *f*, of Riccia glauca, and of the sporangium or spore-case, *o*, which is imbedded in it. *s*, Narrow process or style by which the sporangium communicates with the external surface. *l*. Its cavity or loculus. *s*, Young spores still united in sets of four in the parent cells. *r*, Cells elongated like roots. 2. One of the cells more highly magnified, with the four spores which it contains. Three of the spores are seen, the fourth being concealed by them.

Fig. 412.—Sporangium or spore-case of Marchantia polymorpha. *o*, Hollow swelling containing spores, and which has been compared to the ovary. *t*, Narrow process prolonged upwards and resembling a style. *s*, Termination of this cellular process, compared to the stigma. *c* Cellular covering of the sporangium, or spore-case, surrounding it like a calyx.

ing the spores, and being surrounded by a cellular tube resembling a calyx, *c*. From this ovary-like body there is a prolongation which may be considered as a style, *t*, terminated by a cellular enlargement, *s*, which has been compared to a stigma. The styloid prolongation withers and disappears when the spores are mature. Sometimes the thecæ, as in Lichens, consist of a club-shaped elongated cell or *ascus* (fig. 413, 1), containing nuclei or cells in its interior, which form the spores. Sometimes these are single, at other times united in sets of two (fig. 413, 2), or of four (fig. 411, 2), or of some multiple of four. There are various modifications of sporangia in other Cryptogamic tribes. Thus, in Ferns, they are often surrounded by an annular ring, or by elastic bands, which cause their dehiscence; while in the Chara they are called *nucules*, and present an oval form with a spiral arrangement of tubes.



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460. **The Ovule.**—The ovule is the body attached to the placenta, and destined to become the seed. It bears the same relation to the carpel that marginal buds do to leaves, and when produced on a free central placenta, it may be considered as a bud developed on a branch formed by the elongated axis. The single ovule contained in the ovaries of Compositæ and Grasses, may be called a terminal bud surrounded by a whorl of adhering leaves or carpels, in the axil of one of which it is produced. In Delphinium elatum, Brongniart noticed carpels bearing ovules, which were sometimes normal, at other times mere lobes of the carpellary leaf; and in Aquilegia, Lindley saw ovules transformed into true leaves, produced on either margin of the carpel. Henslow has seen the ovules of Mignonette become leaves. In such cases the vascular bundles of the placenta (*pistillary cords*) are formed by the lateral veins of the carpellary leaf. These veins pass into the marginal lobes or leaflets which represent ovules, and seem to prove that the placenta, in such cases, must be truly a carpellary, and not an axile, formation. Godron, from observing monstrosities, says, that in Leguminosæ, the pericarp, or seed-vessel, is formed by the common petiole dilated, the style is probably the terminal leaflet, or tendril, or *apiculum*, while the ovules represent lateral leaflets of the leaf, and are modifications of it.

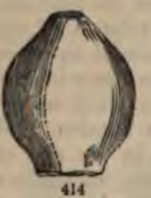
461. The ovule is usually contained in an ovary, but in Coniferæ and Cycadaceæ it has no proper ovarian covering, and is called *naked*. In these orders the ovule is produced on the edges, or in the axil of altered leaves, which do not present a trace of style or stigma. The

Fig. 413.—1. Theca or ascus of Solorina saccata, a species of Lichen, containing eight spores united in sets of two. 2. Two of these double spores highly magnified.

carpellary leaves are sometimes so folded as to leave the ovules exposed, or *seminude*, as in Mignonette. In Leontice thalictroides (blue cohosh), the ovules rupture the ovary immediately after flowering, and the seeds are exposed. So also in species of Ophiopogon, Peliosanthes, and Stateria. In the species of Cuphea, the placenta ultimately bursts through the ovary and corolla, becoming erect, and bearing the exposed ovules.

462. The ovule is attached to the placenta either directly, when it is called *sessile*, or by means of a prolongation called a *funiculus* (*funis*, a cord), *umbilical cord*, or *podosperm* (ποῦς, a foot, and σπέρμα, a seed). This cord sometimes becomes much elongated after fertilization. The placenta is sometimes called the *trophosperm* (τρέφω, I nourish). The part by which the ovule is attached to the placenta or cord, is its *base* or *hilum*, the opposite extremity being its *apex*. The latter is frequently turned round in such a way as to approach the base. The ovule is sometimes imbedded in the placenta.

463 In its simplest form, as in the Mistleto, the ovule presents itself as a small cellular projection, which enlarges, assumes an ovoid form (fig. 414), and ultimately becomes hollowed at the apex (fig. 415 *c*). The cavity thus produced is surrounded by a mass of cells called the *nucleus*, *n*, and is destined to contain the embryo plant after the process of fertilization has been completed. In this embryonal cavity the young plant is suspended by a thread-like cellular process called *suspensor*, attached to the summit of the nucleus. This cavity in some plants is surrounded by the cells of the nucleus; but, in other cases, it becomes lined with a regular *epithelial* (¶ 431), or thin cellular covering, and constitutes the *embryo sac*, which is produced before fecundation, and contains *amnios* or mucilaginous matter in which the embryo is formed.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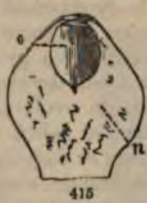


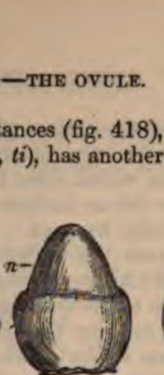
415

464. The nucleus (fig. 421 *n*) may remain naked, and form the ovule, as in the Mistleto, Veronica hederifolia, Asclepias, &c.; but in most plants it becomes surrounded by certain coverings during the progress of development. These appear first in the form of one or more cellular rings at the base, which gradually spread over the surface. In some cases only one covering is formed, as in Compositæ, Campanulaceæ, Walnut, &c. Thus, in the latter (fig. 416), the nucleus, *n*, is covered by a single envelope, *t*, which, in the first instance, extends over the base, and then spreads over the whole surface (fig. 417), leaving only

Fig. 414.—Ovule of the Mistleto entire.

Fig. 415.—Ovule of Mistleto cut to show the embryo-sac, *c*, and the whole of the rest of the mass, *n*, composed of uniform tissue, and forming a nucleus without integuments.

an opening at the apex. In other instances (fig. 418), the nucleus, *n*, besides the single covering (fig. 418, 2, *ti*), has another developed subsequently (fig. 418, 3, *te*), which gradually extends over the first, and ultimately covers it completely. There are thus two integuments, an outer and an inner—the latter, according to Schleiden, being first produced. Mirbel considers the outer as the first formed, and hence has called it *primine*, *te*, while the inner is denominated *secundine*, *ti*. The latter names are in the present day used by botanists as denominating the outer and inner covering, without reference to their order of development. At the apex of the nucleus these integuments leave an opening or foramen composed of two apertures; that in the primine (fig. 418, 3, *ex*), called *exostome* (ἔξω, outside, and στόμα, mouth), that in the secundine (fig. 418, 3, *ed*), *endostome* (ἔνδον, within). The foramen of the ovule is also called *micropyle* (μικρὸς, small, and πύλη, a gate): but this name is often restricted to its appearance in the seed after fecundation. The length of the canal of the foramen depends on the development of the nucleus, as well as the thickness of the integuments. The embryo-sac is sometimes prolonged beyond the apex of the nucleus, as noticed by Meyen in Phaseolus and Alsine media, and by Griffith in Santalum album and Loranthus. Some authors, as Mirbel, consider the ovule in reference to the embryo, and speak of five coverings of the latter, viz., 1. primine; 2. secundine; 3. tercine, or the nucleus; 4. quartine, a temporary cellular layer, which is occasionally formed at an after period around 5. quintine, or the embryo-sac. By most botanists the nucleus and sac with its two integuments are mentioned as the ordinary structure of the ovule.



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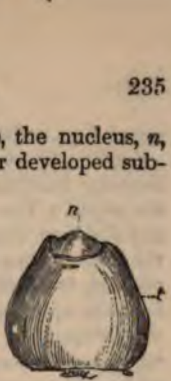

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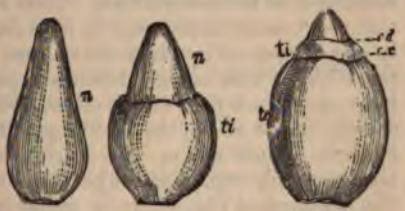


418, 1 418, 2 418, 3

465. All these parts are originally cellular. The nucleus and integuments are united at the base of the ovule by a cellulo-vascular

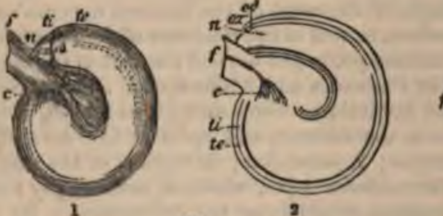
Fig. 416.—Ovule of Juglans regia, the Walnut. *t*, Simple integument. *n*, Nucleus, the base of which only is covered with integument at the early period of development.

Fig. 417.—The same ovule more advanced, in which the nucleus is nearly completely covered.

Fig. 418.—Ovule of Polygonum cymosum at various ages. *n*, Nucleus. *te*, The outer integument or primine. *ti*, The inner integument or secundine. *ex*, Exostome or opening in the primine. *ed*, Endostome or opening in the secundine. 1. Ovule in the early state, when the nucleus is still naked. 2. Ovule in second stage, when the nucleus is covered at its base by the internal integument or secundine only. 3. Ovule in the third stage, when the two integuments, primine, and secundine, form a double covering, at the apex of which the nucleus still appears.

membrane, called the *chalaza* (fig. 421 *ch*). This is often colour
a denser texture than the surrounding tissue, and is traversed by
vascular bundles, which come from the placenta, in order to no
the ovule. The hilum indicates the organic base of the ovule,
the foramen marks its apex. When the ovule is so developed
the union between the primine, secundine, and nucleus with
chalaza, is at the hilum or base (next the placenta), and the for
is at the opposite extremity (figs. 417, 418), the ovule is *orthotr*
orthotrovous, or *atropous* (ὀρθὸς, straight, and τρόπος, mode, or α
vative, and τρέπω, I turn). This is the state of an ovule when it
makes its appearance, and occasionally, as in Polygonaceæ, it re
permanent. In such ovules, a straight line drawn from the hilu
the foramen passes through their axes.

466. In general, however, changes take place on the ovule, so t
deviates from the straight line. Thus it may be curved upon its
that the foramen approaches to the hilum or placenta, and ultim
is placed close to it, while the chalaza is only slightly removed
the hilum. This change depends apparently on the ovule incre
more on one side than on the other, and as it were drawing the ch
slightly to one side of the hilum opposite to that where the foram
applied. Such ovules are called *campylotropal* or *campylotr*
(καμπύλος, curved), when the portions on either side of the line of c
tion are unequal (fig. 419); or *camptotropal* (καμπτὸς, curved),



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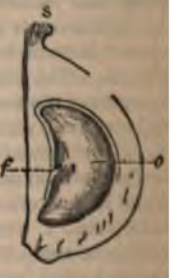


420

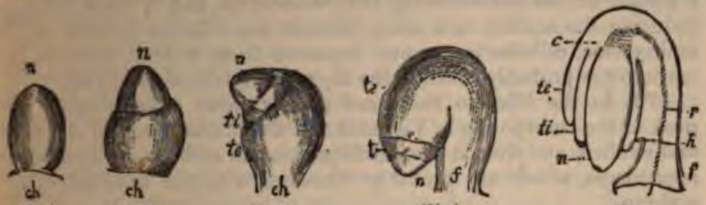
they are equal (fig. 420). Curved ovules are found in Legumin
Cruciferæ, and Caryophyllaceæ. The union between the parts o
curved portion usually becomes complete, but in some cases th
no union, and the ovules are *lecotropal*, or horse-shoe shaped (λ
hollow disk, and τρόπος, mode or form).

467. When in consequence of the increase on one side, the ov

Fig. 419.—Campylotropal or Campylotropous ovule of the Stock. 1. Ovule entire. 2.
cut lengthwise. *f*, Funiculus or umbilical cord. *c*, Chalaza. *n*, Nucleus. *te*, Primine or
covering. *ti*, Secundine or inner covering. *ex*, Exostome. *ed*, Endostome.

Fig. 420.—Carpel of Menispermum canadense, with a curved or camptotropal ovule,
Funiculus. *s*, The base of the style.

so changed that its apex or foramen (fig. 421, 4, *n*), is in close apposition to the hilum (fig. 421, 5, *h*) and the chalaza is also carried round so as to be at the opposite extremity (fig. 421, 5, *c*), then the ovule becomes inverted, *anatropal* or *anatropous* (ἀνατρέπω, I subvert). In this case (fig. 422), the union of the chalaza, *ch*, with the nucleus, *n*, is removed from the hilum, and the connection between the chalaza and placenta is kept up by a vascular cord, *r*, passing through the funiculus, and called the *raphe* (ῥάφη, a line). The raphe often forms a ridge along one side of the ovule, and it is usually on the side of the ovule next the placenta. Some look upon this kind of ovule as formed by an elongated funiculus (fig. 421, 5, *f*) folded along the side of the ovule, and becoming adherent to it completely; and support this view by the case of *semi-anatropal* ovules, where the funiculus is only, as it were, partially attached along one side, becoming free in the middle; and also by cases where an anatropal ovule, by the separation of the funiculus from its side, becomes an orthotropal seed.



421, 1 421. 2 421, 3 421, 4 421, 5

Fig. 421.—Ovule of Chelidonium majus at different stages of development. *h*, Hilum or umbilicus. *ch*, Chalaza. *f*, Funiculus or umbilical cord. *r*, Raphe. *n*, Nucleus. *ti*, Secundine. *te*, Primine. *ed*, Endostome. *ex*, Exostome. 1. First stage: nucleus still naked. 2. Second stage: nucleus covered at its base by the secundine. 3. Third stage: the primine developed and covering the secundine at its base. 4. Fourth stage: the ovule completely reflected, and its point turned downwards. 5 The same cut longitudinally, to show the relation of its different parts.

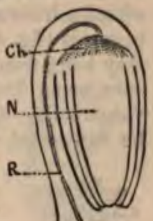


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Fig. 422.—Anatropous ovule of Dandelion, cut vertically. *ch*, Chalaza. *r*, Raphe. *n*, Nucleus.

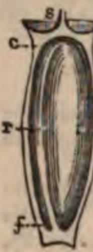
468. The anatropous form of the ovule is of very common occurrence, and may probably aid in the process of fertilization. Ovules which are at first orthotropous, as in Chelidonium majus (fig. 421, 2), become often anatropous in the progress of development (fig. 421, 4). When the ovule is attached to the placenta, so that the hilum is in the middle, and the foramen and chalaza at opposite ends, it becomes transverse, *amphitropal* or *heterotropal* (ἀμφὶ, around, ἕτερος, diverse).

469. The nucleus of the ovule becomes hollowed at a particular part (fig. 415 *c*), so as to form a cavity. Mirbel states that the whole nucleus is transformed into a membrane called the *tercine*, lining the secundine, and that in its interior another covering, the *quartine*, and

finally, the embryo-sac, are produced. The view, however, generally adopted, is that the embryo-sac is formed within the nucleus, assuming a greater or less size according to circumstances, and in some instances reducing the nucleus to a mere external sac. In the interior of the embryo-sac, cellular layers are deposited from without inwards, the earlier ones probably forming the fugacious quartine of Mirbel.

470. In the Mistleto there are two or three embryo-sacs. The neck of the embryo-sac in Veronica and Euphrasia becomes elongated and swollen, and from it are developed certain cellular or filamentous appendages, which are probably connected with the nutrition of the embryo.

471. The position of the ovule relative to the ovary varies. When there is a single ovule, it may be attached to the placenta at the base of the ovary (*basal placenta*), following a straight direction, and being *erect*, as in Polygonaceæ and Compositæ (fig. 423); or it may be inserted a little above the base, on a parietal placenta, with the apex upwards (fig. 424), and then is called *ascending*, as in Parietaria. It may hang from an apicilar placenta at the summit of the ovary, the apex being downwards, and be *inverted* or *pendulous*, as in Hippuris vulgaris (fig. 425), or from a parietal placenta near the summit, and be *suspended*, as in Daphne Mezereum (fig. 426), Polygalaceæ, and Euphorbiaceæ. Sometimes a long funiculus arises from a basal placenta, reaches the summit of the ovary, and suspends the ovule, as in Armeria; at other times the hilum or true organic base appears to be in the middle, and the ovule becomes *horizontal*, *peltate* (*pelta*, a shield), or *peritropous* (περὶ, around, and τρέπω, I turn). All these modifications are influenced by the relative position of the hilum and



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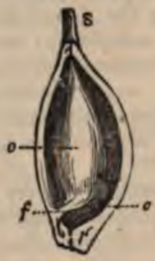

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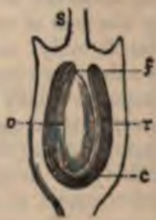

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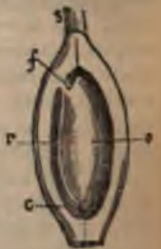

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Fig. 423—426.—Carpels belonging to different flowers, cut vertically to show the different directions of the solitary ovule, *o*, contained in them. *f*, Funiculus. *r*, Raphe. *c*, Chalaza. *s*, Base of the style.

Fig. 423.—Carpel of Senecio vulgaris, with a straight or erect anatropous ovule.

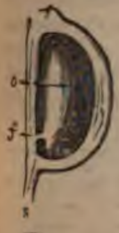
Fig. 424.—Carpel of Parietaria officinalis, pellitory, with an ascending orthotropous ovule.

Fig. 425.—Carpel of Hippuris vulgaris, Mare's-tail, with a reversed or pendulous anatropous ovule.

Fig. 426.—Carpel of Daphne Mezereum, with a suspended anatropous ovule.

foramen, the length of the funiculus, and its adhesion, as well as the position of the placenta.

472. When there are two ovules in the same cell, they may be either *collateral*, that is, placed side by side (fig. 427), or the one may be erect and the other inverted, as in some species of Spiræa and Æsculus (fig. 428), or they may be placed one above another, each following the same direction. Such is also the case with ovaries containing a moderate or definite number of ovules. Thus, in the ovary of Leguminous plants (fig. 429), the ovules, *o*, are attached to the extended marginal placenta, one above the other, forming usually two parallel rows corresponding to each margin of the carpel. When the ovules are *definite* (uniform, and can be counted), it is usual to find their attachment so constant as to afford good characters for natural orders. When the ovules are very numerous or *indefinite*, while at the same time the placenta is not much developed, their position exhibits great variety, some being directed upwards, others downwards, others transversely (fig. 430), and their form is altered by pressure into various polyhedral shapes. In such cases it frequently happens that some of the ovules are arrested in their development and become abortive. In Cryptogamous plants, in place of ovules there are cellular bodies called *spores*, to which allusion will be made when the seed is considered.



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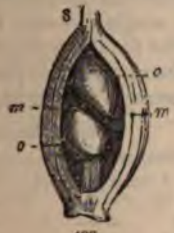

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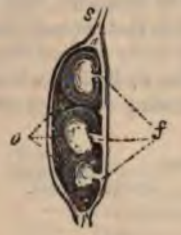

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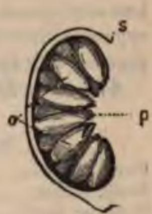


430

4.—FUNCTIONS OF THE FLORAL ENVELOPES.

473. The bracts and calyx, when of a green colour, perform the same functions as leaves, giving off oxygen under the influence of light, and producing the substance called chlorophyll or phytochlor. They

Fig. 427.—Carpel of Nuttallia cerasoides. with two suspended collateral ovules. *o*, One of the ovules. *f*, Funiculus *s*, The base of the style.

Fig. 428.—One of the loculaments of the ovary of Æsculus hybrida, laid open to show two ovules, *o o*, inserted at the same height, but turned in different directions. *m m*, Micropyle indicating their apex. *s*, Base of the style.

Fig. 429.—Carpel or legume of Ononis rotundifolia, with several campylotropous ovules, *o*, placed one above the other. *f*, Funiculi. *s*, Base of the style.

Fig. 430.—Loculament of the ovary of Peganum Harmala, with numerous ovules, *o*, attached to a projecting placenta, *p*, and pointing in different directions. *s*, Base of style.

are consequently concerned in the assimilation of matters fitted for the nutrition of the flower, and they aid in protecting the central organs. The corolla does not in general produce chlorophylle, nor does it give off oxygen. On the contrary, it absorbs oxygen from the air. A the same time that oxygen is absorbed there is a conversion of starch into grape sugar, an evolution of carbonic acid gas, and in many instances a very marked elevation of temperature, caused by the com bination between the carbon of the flower and the oxygen of the air The starch, which is stored up in the receptacle and at the base of th petals, by passing into the state of dextrin and grape sugar, become fitted for vegetable nutrition. At the same time important purpose are served in the economy of the plant. Thus the saccharine an honey-like matter which often collects in the cup of the flower, an sometimes in special pits or depressions, as in Crown Imperial, an Asarabacca, attracts bees and various insects, which are thus mad instrumental in scattering the pollen. The quantity of oxygen absorbe was determined by Saussure. He found that double flowers absorbe less in proportion to their volume than single flowers; that the essentia organs contained more oxygen than the floral envelopes; and that th greatest absorption took place when the stamens and pistil were mature

474. The following are some of Saussure's experiments:—

Name.	Duration of Experiment.	Oxygen Consumed—			
		By Flowers entire.		By essential Orga only.	
Stock, single	24 hours.	11·5	times their vol.	18·	times their
Stock, double	—	7·7	——	—	——
Tuberose, single	—	9·	——	—	——
Tuberose, double	—	7·4	——	—	——
Indian Cress, single	—	8·5	——	16·3	——
Indian Cress, double	—	7·25	——	—	——
Brugmansia arborea	—	9·	——	—	——
Passiflora serratifolia	—	18·5	——	—	——
Gourd, male flower	10 —	7·6	——	16·	——
Gourd, female	24 —	8·5	——	—	——
Hibiscus speciosus	12 —	5·4	——	6·3	——
Hypericum calycinum	24 —	7·5	——	8·5	——
Cobæa scandens	—	6·5	——	7·5	——
Arum italicum	—	—	——,	30·	——
Typha latifolia	—	9·8	——	—	——
White lily	—	5·	——	—	——
Castanea vulgaris	—	9·1	——	—	——

475. While this oxidation is going on, carbon is given off in th form of carbonic acid, and heat is developed by the combination betwe the oxygen and carbon. The quantity of carbonic acid given off is i a ratio to the amount of oxygen absorbed, and the degree of he present proportionate to the activity of the chemical and vital chang going on. Experiments have been performed by Lamarck, Schult Huber, Saussure, Brongniart, Vrolik, and De Vriese, as to th *amount of heat* produced during flowering, especially by species

Arum, Caladium, and Colocasia. These are plants in which the floral envelopes are nearly absent, while the essential organs, the torus and growing point, attain a high degree of development, forming a spadix enclosed in a large spatha. No heat could be detected when the contact of oxygen was prevented, either by putting the plants into other gases, or by covering the surface of the spadix with oil. The surface of the spadix is the part whence the heat was chiefly evolved. The Arum cordifolium occasionally had a temperature 20° or 30° above that of the surrounding air, Arum maculatum 17° to 20°; and Arum Dracunculus and other species still higher. The following observations were made by Brongniart on the spadix of Colocasia odora. The spathe opened on the 14th of March; the discharge of pollen commenced on the 16th, and continued till the 18th. The maximum temperature occurred at different hours.

	Maximum.	Temperature above the Air.
14th March.	3 P.M.	4·5° Cent.
15th —	4 —	10·0°
16th —	5 —	10·2°
17th —	5 P.M.	11·0° Cent.
18th —	11 A.M.	8·2°
19th —	10 —	2·5°

476. Vrolik and De Vriese made a series of observations on the same plant, and have given the results for every half-hour. The following are some of these results:—

Hour.	Temperature of Plant.	Temperature of Air.
11-30	20·6° Cent.	18·3° Cent.
12	21·1 —	18·7 —
12-30	23·3 —	19·4 —
1	24·4 —	19·4 —
1-30	24·4 —	18·9 —
2	25·6 —	17·2 —
2-30	26·5 —	15·6 —
3	25·0° Cent.	15·6° Cent.
3-30	24·4 —	15·0 —
4	23·3 —	15·0 —
5	22·2 —	18·7 —
6	21·0 —	18·7 —
7	20·0 —	18·7 —

The greatest amount of heat observed was at 2-30 P.M., when it was 10·9° above the temperature of the air. On the previous day the maximum occurred at 3 P.M., and on the following day at 1, but then it was only 8·2° above that of the air. Decandolle states that at Montpelier, Arum italicum attained the maximum of temperature about 5 P.M. Saussure observed similar phenomena, but to a less extent, in the Gourd, where the temperature varied from 1·8° to 3·6°; also in Bignonia radicans, from 0·9° to 3°. From all these experiments, it would appear that in the Araceæ and some other plants, especially at the period when the essential organs reach maturity, there is a production of heat, which increases during the performance of their functions, attaining a daily maximum, and ultimately declining.

477. While these changes are taking place, the starch is converted into dextrine, and ultimately into grape-sugar, which, being soluble,

can be immediately applied to the purposes of the plant. The
like matter thus formed is stored up frequently at the base
petals, in little pits or nectaries, as in Fritillary, Asarum, &c.
considered by Vaucher and others as performing an importan
in fertilization, covering the stigma, and aiding in the dispersi
rupture of the pollen-grains. Bees and other insects, in co
the saccharine matter, also scatter the pollen.

478. Flowering takes place usually at a definite period of the
existence. It requires a considerable amount of nutrient matt
its occurrence is accompanied with a greater or less exhaustion
assimilated products. Hence, a certain degree of accumulation
seems necessary in order that flowering may proceed. Annual
are so exhausted after flowering as to die; but, by retarding th
for two or more years, as by nipping off the flower-buds,
allowed for accumulating sap; the stems, from being herbaceo
come shrubby, and sometimes, as in the Tree-Mignonette, they
made to live and flower for several years. Perennial plants,
retardation of flowering, are enabled to accumulate a greater
of nutritive matter, and thus to withstand the exhaustion. Ma
tivated plants which lay up a large store of nutriment in the
starch, lose it when the plants shoot out a flowering stem.
seen in the case of Carrots and Turnips, in which the succule
become fibrous and unfit for food when the plants are allowed
to seed. The receptacle of the Artichoke and many Compositæ,
is succulent before the expansion of the flowers, becomes dry
process of flowering proceeds. The juices of plants, then,
required for the purpose either of food or medicine, ought in
to be collected immediately before flowering.

479 By cutting a ring out of the bark of trees, and thus re
the descent of the sap, the period of flowering is sometimes ha
Again, when the period of flowering is long delayed, either na
as in Agave and several palms, or artificially, the process, when
begin, proceeds with amazing rapidity and vigour. In such ca
vigorous flowering is often followed by the death of the plant.
mentions, that a plant of Agave, which had not flowered for n
century, sent out a flowering stem of 22½ feet in 87 days, incre
one period at the rate of one foot a-day. Common fruit tree
they begin to flower, often do so luxuriantly; but if, from the
being bad, there is a deficiency in flowering, it frequently happe
from the accumulation of sap, the next year's produce is abund

480. If plants are allowed to send out their roots very exte
in highly nutritive soil, the tendency is to produce branches an
rather than flowers. In such cases, cutting the roots or prun
young twigs may act beneficially in checking the vegetative fu
In pruning, the young shoot is removed, and the buds connect

previous year are left, which thus receive accumu-
. Grafting, by giving an increase of assimilated
or graft (see section on Fruiting), and at the same
xuriant branching, contributes to the hastening of

d of flowering of the same plant varies at different
fferent countries. During the winter in temperate
ng the dry season in the tropics, the vegetative pro-
ore especially by the diminished supply of moisture,
nt of the circulation of the sap. The assimilated
a state of repose, ready to be applied to the purposes
the moisture and heat again stimulate the vegetable
timulation occurs at different periods of the year,
nature of the climate. By observing the mode of
ame species of plant in successive years, conclusions
to the nature of the seasons in a country; and by
periods in different countries, comparisons may be
he nature of their climate. Thus valuable floral
constructed.

accommodated to the climate in which they grow,
tain seasons, and even when transferred to other
seasons are reversed, they still have a tendency to
customed period of the year. Again, in the same
ividuals of a species, from a peculiar idiosyncrasy,
arlier than others. Decandolle mentions a horse-
a, which flowered always a month before the rest
ood. From such individuals, by propagation, gar-
produce early-flowering varieties.

periodicity in the hours of the day at which some
flowers. Some expand early, some at mid-day,
ning. The flowers of Succory open at 8 A.M., and
those of Tragopogon porrifolius, or Salsafy, close
Linnæus constructed a floral clock or watch, in
it hours were marked by the expansion of certain
iods, however, do not seem to be always so regular
hem at Upsal. The following are a few of these
, with their hours of opening:—

	3 to 4 A.M.
atense	4 .. 5 —
ule	5 —
aculata	6 —
of Sonchus and Hieracium	6 ... 7 —
	7 —
culum	7 ... 8 —
rialis	
nsis	8 —

Nolana prostrata	8 to 9 A.M.
Calendula arvensis	9 —
Arenaria rubra	9...10 —
Mesembryanthemum nodiflorum	10...11 —
Ornithogalum umbellatum (*Dame d'onze heures*)	11 —
Various Ficoideous plants	12 —
Scilla pomeridiana	2 P.M.
Silene noctiflora	5 ... 6 —
Œnothera biennis	6 —
Mirabilis Jalapa	6 ... 7 —
Cereus grandiflorus	7 ... 8 —

484. Plants which expand their flowers in the evening, as so species of Hesperis, Pelargonium, &c., were called by Linnæus *pla* *tristes* on that account. Several species of Cooperia, and of Cer also Sceptranthus Drummondii, are nocturnal flowers. Some flow open and decay in a day, and are called *ephemeral*, others continu open and close for several days before withering. The corolla usu begins to fade after fecundation has been effected. Many flowers heads of flowers, do not open during cloudy or rainy weather, have been called *meteoric*. Composite plants frequently exhibit phenomenon, and it has been remarked in Anagallis arvensis, wh has hence been denominated the "poor man's weather-glass." closing of many flowers in such circumstances protects the pollen f the injurious effects of moisture.

485. The expansion and closing of flowers is regulated by light moisture, and also by a certain law of periodicity. A plant accusto to flower in day-light at a certain time, will continue to expand flowers at the wonted period, even when kept in a dark room. De dolle made a series of experiments on the flowering of plants in darkness, and in a cellar lighted by lamps. He found that the of periodicity continued to operate for a considerable time, and in artificial light some flowers opened, while others, such as spe of Convolvulus, still followed the clock hours in their opening closing.

486. Light has been said also to have an effect on the direc which flowers assume. Some Compositæ, as Hypochæris radicata Apargia autumnalis, are stated by Henslow to have been seen meadows, where they abound, inclining their flowers towards quarter of the heavens in which the sun is shining. A similar st ment has been made regarding the Sun-flower, but it has not confirmed in this country at least. Perhaps in its native clime, wh the effect of the sun's rays is greater, the phenomenon alluded to be observable. Vaucher mentions the effects of light on the direc of the flowers of many plants, as Narcissuses and certain specie Melampyrum.

487. It is of importance, both as regards meteorology and bota

phy, that observations should be made carefully on what are the annual and diurnal periods of plants: the former being the f time computed between two successive returns of the leaves, vers, and the fruit; and the latter, the return of the hour of the which certain species of flowers open. The same species should cted in different localities, and care should be taken that the re such as have determinate periods of flowering. Rules as to de of observing periodical phenomena in plants have been up by the British Association, and a committee has been ap- to carry this into effect. The committee has published (1.) a lants to be observed for the periods of foliation and defoliation: ist of plants to be noticed for flowering and ripening of the 3.) a list of plants to be observed at the vernal and autumnal es, and summer solstice, for the hours of opening and closing wers.

CTIONS OF THE STAMENS AND PISTIL—FERTILIZATION OR FECUNDATION.

The stamens and pistil are called the *Essential Organs* of g plants, inasmuch as without them reproduction cannot be . In plants which do not flower, this function is performed ial organs, which have been termed antheridia and archegonia, ccomplished by a process of conjugation or union of cells. mens, considered as the male organs, prepare the pollen, which arged by the dehiscence of the anther. The pistil, or the organ, is provided with a secreting surface or stigma, to which len is applied in order that the ovules contained in the ovary fertilized.

The existence of separate sexes in plants appears to have been red in early times, as shown by the means taken for perfecting t of the Date Palm. In this palm, the stamens and pistils are rate plants; and the Egyptians were in the habit of applying le flowers to those in which the rudiments of the fruit appeared, that perfect dates might be produced. This practice appears been empirical, and not founded on correct notions as to the the plant concerned in the process. In the case of the Fig, re in the habit of bringing wild figs in contact with the culti- nes, on the erroneous supposition that a similar result was pro- s in the case of the Date, proving that they were not aware of , that in the Fig there are stamens and pistils present on the ceptacle. The effect produced by the wild figs, or the process *fication* (*caprificus*, a wild fig-tree), as it was called, seems to on the presence of a species of Cynips, which punctures the d causes an acceleration in ripening. The presence of sexual n plants was first shown in 1676, by Sir Thomas Millington,

Savilian Professor at Oxford, and Grew. The opinions of thes
ralists were subsequently confirmed by Malpighi, Ray, M
Geoffrey, and others. Linnæus made these organs the basis
artificial system of classification.

490. Numerous proofs have been given of the functions
stamens and pistils, especially in the case of plants where these
are in separate flowers, either on the same or on different plants.
a pistilliferous specimen of Palm (Chamærops humilis), in the
Botanic Garden, which had long been unproductive, was made
duce fruit by shaking over it the pollen from a staminiferous sp
The same experiment has on several occasions been performed
Botanic Garden at Edinburgh, and the fruit thus ripened has fu
seeds which have germinated. Similar results were observed
case of the Pitcher plant. In Cucumbers, when the stamin
flowers are removed, no perfect fruit is formed. Removing the s
in the very early state of the flower, before the pollen is p
formed, prevents fertilization. Care must be taken, in all such
ments, that pollen is not wafted to the pistil from other plants
neighbourhood, and the result must be put to the test by the g
tion of the seed; in some instances, the fruit enlarges independ
the application of the pollen, without, however, containing perf
Thus, a species of Carica was fertilized by the application of poll
produced perfect fruit and seed, and it continued for at least o
afterwards to have large and apparently perfect fruit, but the
were abortive.

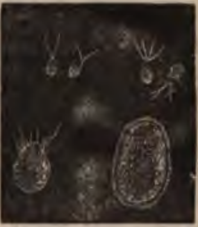
491. Some authors maintain, that in the case of Hemp, S
Lychnis dioica, Cœlebogyne, and some other plants, perfect see
been produced without the influence of pollen; and these stat
have been lately confirmed. Such cases are recorded as exam
true Parthenogenesis, or the production of perfect seeds withou
lization. In Phanerogamous or flowering plants in general, ho
all experiments lead to the conclusion that there are distinct
organs.

492. In Cryptogamous or flowerless plants, considerable
have been entertained as to the existence of such organs.
simplest form of Cryptogamic plants, as the unicellular Red
reproduction and nutrition progress within the same cell.
ascend in the scale of vegetation, and the plant becomes more co
there seem to be cells of different kinds, which require to be b
into contact in order that spores (which are equivalent to seed
be produced. These reproductive cells are of two kinds, an
are situated either together or apart, on the same or on d
individuals. One of these is the *Antheridium*, a cellular body c
ing granular matter, and *Phytozoa* (φυτὸν, a plant, and ζωός,
or minute bodies which exhibit movements; the other is the

or *Archegonium* (ἀρχή, beginning, and γόνος, offspring), containing s which germinate, and which are sometimes provided with cilia 431—434), so as to become *Zoospores* , living, and σπορά, a seed or spore), or ng spores. These phytozoa have been ded as exercising a function similar to of the spermatozoa in animals, and hence are sometimes called Spermatozoids. A tion of their active movements has been rved coincident with the earliest forma- of the embryo. Hofmeister states, that he ften seen spermatozoids swimming about nd the archegonium, in longitudinal sections e involucres of Jungermanniæ; he has also them in a motionless state after the rudiment of the fruit began e developed. When the contents of the antheridia and arche- a are brought into contact, a cellular body is produced in the r. This cell or germ, when mature, may either be discharged, ay remain in connection with the plant until further developed. lgæ, antheridia have been found containing phytozoa, and pis- ia containing zoospores. The same has been observed in Fungi Lichens. Mosses having antheridia and archegonia on the stem generally prove fruitful; when these organs are situated lifferent plants, unless they are in close proximity one to the r, fructification does not result. The contact of the Antheridium Pistillidium or Archegonium is necessary for the fertilization of pore. In other cases, as in Confervæ and Diatomaceæ, there is ion of the cells of the plant by *conjugation*, so as to produce inating bodies. In these cases, the contents of one cell pass, by ormation of a tube, into the other. In Zygnema, this conjugation rise to germinating bodies in the interior of one of the cells of lant; in Diatomaceæ, on the outside of the cells.

3. The union of two kinds of *endochrome* (ἔνδον, within, and χρῶμα, ur), or of two kinds of coloured particles, appears in these plants ve rise to the sporangium or spore-case, and the spore. Some- the two kinds of endochrome are in separate plants, as already ed, and then conjugation unites them, and causes a mixture of the chrome; while in Meloseira, &c., the different kinds are apparently ed in different parts of the same cell, and movements take place ds the centre, by which their union is effected and a spore pro- l. In Ferns, Mosses, &c., there have been detected separate

431 432



433 434

Fig. 431.—434.—Spores of different fresh-water Algæ.
Fig. 431.—Spores of a Conferva, with two vibratile cilia.
Fig. 432.—Spore of a Chætophora, with four cilia.
Fig. 433.—Spore of a Prolifera, with a circle of cilia.
Fig. 434.—Spore of a Vaucheria, covered with cilia.

cellular bodies, the union of which is considered necessary for
perfection of the spores. In Ferns, the spore, when germinating, fo
in the first instance a cellular expansion called a prothallus. On
prothallus, antheridia and archegonia appear. The former consis
a cellular papilla having a central cavity containing free cell
which cellules, when escaping from the investing papillary membr
discharge ciliated spiral filaments or spermatozoids. The archego
which also exist on the surface of the prothallus, consist of cell
papillæ, in the centre of which may be traced a closed canal lead
to a cell or ovule, which is embedded in the substance of the
thallus, and contains within it the embryo germ. The spermatoz
come into contact with this embryonic cell, which ultimately beco
matured, and finally (while still attached to the prothallus) g
origin to the proper frond, bearing sporangia and spores. In L
pods the small spores contain cellules with spermatozoids, while
large spores contain a cellular prothallus in their interior, on w
archegonia are developed. By the contact of these two bo
the embryo plant is produced. Similar bodies also exist in Rh
carps. In many Cryptogamic plants the formation of new
by a constant process of fissiparous or merismatic division (¶
may be considered as analogous to the formation of buds, depend
perhaps on certain changes similar to fecundation going on in
interior.

494. In flowering plants, various provisions are made for insu
the application of the pollen to the stigma. The comparative le
of the stamens and pistils, their position, and the dehiscence of
anthers, are all regulated with this view. The existence of spiral
in the endothecium has reference apparently to the bursting of
anther, and the scattering of the pollen. The number of pollen-gr
produced is also very great. Hassall says that a single head of Da
lion produces upwards of 240,000, each stamen of a Pæony 21,00
Bulrush 144 grains by weight. It has been stated, that a single
of Wisteria sinensis produced, 6,750,000 stamens, and these, if per
would have contained 27,000,000,000 pollen-grains.* In the ca
Evergreens, such as Firs, the quantity of pollen is enormous, a
rently to insure its application notwithstanding the presence of le
The pollen from pine forests has been wafted by the winds to a
distance, and is said to have fallen on the ground like a show

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* The following estimate was made of the amount of flowers, stamens, &c., in a single sp
of Wisteria sinensis:—

Number of clusters of Flowers	9,000
——— individual Flowers	675,000
———Petals	3,375,000
———Stamens	6,750,000
———Ovules	4,050,000

For the purpose of fertilizing these ovules, the anthers, if perfect, would have contained
27,000,000,000 pollen-grains, or about 7000 grains to each ovule.

sulphur. It is thus that some kinds of coloured rain, occasionally witnessed, may be accounted for. The pollen powder transmitted to considerable distances remains floating in the air till carried down by some descending shower.

495. The quantity of pollen required for impregnation varies. Koelreuter says, that from fifty to sixty grains of the pollen of Hibiscus Trionum are required to fecundate the fruit completely, containing about thirty ovules. The ovary of Nicotiana, Datura, Lychnis, and Dianthus, according to Gærtner, may be completely fertilized by the pollen of a single perfect anther. In Geum, from eight to ten anthers, out of eighty-four to ninety-six contained in each flower, are sufficient to fertilize from eighty to one hundred and thirty ovules contained in the ovary.

496. In many trees in which the organs of reproduction are in separate flowers (as Hazel and Willow), the leaves are not produced until fertilization has been effected. The protection of the pollen from the direct influence of moisture, is effected by the closing of the flowers, by the elasticity of the anther-coat only coming into play in dry weather; and in aquatics, either by a peculiar covering, as in Zostera, or by the flowers being developed above water, as in Nymphæa, Lobelia, Stratiotes, and Hottonia. In Vallisneria spiralis, a plant growing in the mud of ditches, the staminiferous plants are detached from the soil, float on the surface of the water, and produce there flowers and pollen; while the pistilliferous plants send up a long peduncle (fig. 228), which accommodates itself to the depth of the water by being spiral, and bears on its summit the flower with the pistil. By this means the two organs are brought into contact, and fertilization is effected. Lagarosiphon muscoides, an aquatic plant from Africa, shows similar phenomena in regard to impregnation as are seen in Vallisneria. When continued wet weather comes on after the pollen has been matured, and has begun to be discharged, it often happens that little or no fruit is produced. In flowers where the anthers burst in succession, the injury done by moisture is less likely to extend to all.

497. In some plants the stamens, at a certain period of their development, move towards the pistil, so as to scatter the contents of the anther. In Parnassia palustris and Rue, they do so in succession. In Kalmia, the anthers are contained in little sacs or pouches of the corolla, until the pollen is mature, and when the expansion of the corolla, and the elasticity of the filament, combine to liberate them, they spring towards the pistil with a jerk. In Parietaria officinalis, and in the Nettle, the spiral filament is kept in a folded state until the sepals expand, and then it rises with elastic force and scatters the pollen. Similar phenomena are observed in the Cornus canadensis. In the various species of Barberry, the inner and lower part of the filament is irritable, and

when touched it causes the stamen to move towards the pistil. This takes place naturally when the anther is ripe, and the recurved valves covered with pollen are ready to be applied to the stigma. The species of Stylidium have their anthers and stigma seated on a column, the base of which is slightly swollen and irritable. When a stimulus is applied, this column passes with considerable force from one side of the flower to the other, rupturing the anther lobes, and thus aiding in fertilization.

498. In certain plants the agency of insects is employed to insure fecundation. In species of Aristolochia, the tube of the calyx completely encloses the organs of reproduction, and the stamens are placed below the stigma, so that the pollen can neither be applied directly, nor be carried by the winds. These plants are said to be frequented by insects, which enter the tubes and reach the little chamber at the base, with the view of collecting saccharine matter. The deflexed hairs in the interior of the tube prevent their escape, and in their movements they apply the pollen to the stigma. When this is accomplished, the flower withers, and the insects escape. Orchidaceous plants have remarkable flowers, which resemble bees, flies, spiders, and in general the insects of the country in which they grow. The special odour of these flowers, and the large quantity of honey-like matter connected with the essential organs, also attract insects to them. These insects, in searching for food, detach the pollen masses, which are easily removed from the clinandrium, or the part of the column on which they are placed, and then naturally fall on the stigmatic surface. Asclepiadaceæ have also pollinia, and attract insects by their fetid odour in some cases. Bees and aphides may in many instances, contribute to the process of fertilization.

499. While the pollen is being elaborated, the stigma is also undergoing changes. It becomes enlarged, and secretes a viscid matter ready to detain the pollen-grains when they are discharged. This secretion was represented by Dr. Aldridge to be, in some cases, acid, but it seems more generally to be of a mucilaginous or saccharine nature. Vaucher thinks that the nectariferous fluid usually found in the flower spreads itself over the stigma, and that it is sometimes instrumental in conveying the pollen-grains. In Goldfussia or Ruellia anisophylla, and the species of Campanula, as media, Rapunculoides, and Trachelium, the style is covered with collecting hairs, which appear to aid in the application of the pollen. In the first-mentioned plant, a remarkable curvation of the style takes place, so as to make the stigma come into contact with the hairs. In Campanula, the hairs on the upper part of the style seem to collect the pollen, and allow it to be applied to the revolute branches of the stigma. In this genus the style is at first
tly longer than the stamens, but it soon becomes twice their length,
uring its elongation, the hairs upon it brush the pollen-grains

ut of the anther cases, and thus raise them into a position where they an be applied ultimately to the stigmatic surface. The stigma con- sts of two branches, which are at first erect, but afterwards, by hanges in the cells, become completely revolute, so as to come into ntact with the hairs. After the hairs have perfomed their office, eir fine inner membrane collapses by a process of endosmose, and the ff outer membrane is drawn inwards, so as to retire within its cell. fter the pollen reaches the stigma, changes take place in it, by which e fovilla contained in the intine of the grains is allowed to escape. his fovilla consists of minute molecules exhibiting certain movements, hich by some have been considered analogous to those of phytozoa Cryptogamic plants, or spermatozoa in the animal kingdom. Others k upon these motions as entirely molecular.

500. The length of time during which the pollen retains its vitality, power of effecting fertilization, varies in different plants. Accord- g to Gærtner and others, the pollen of some species of Nicotiana tains its vitality only for forty-eight hours; pollen of various species Datura, two days; pollen of Dianthus Caryophyllus, three days; llen of Lobelia splendens, eight or nine days; pollen of Cheiranthus heiri, fourteen days; pollen of Orchis abortiva, two months; pollen of andollea, one year; pollen of Date Palm, one year or more. Michaux ys, that in some Palms, as Date and Chamærops humilis, the pollen ay be applied successfully after having been carefully kept for ghteen years. The pollen retains its vitality longer when not removed om the anthers, and the finer it is, the more quickly it loses its cundating property.

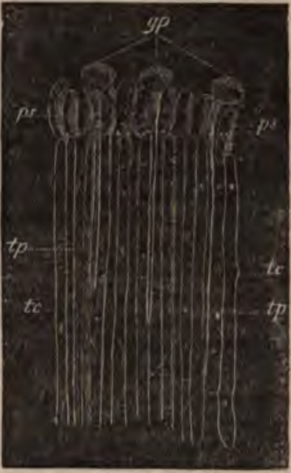
501. **Theories of Embryogeny.**—So far as the application of the ollen to the stigma is concerned, the process of fertilization can be asily traced, but the changes which are subsequently produced on he pollen-grain and the ovule are very obscure, require minute icroscopic research, and have led to numerous conflicting theories f Embryogeny. It has been already stated that some physiologists, specially Bernhardi, believe, that in the case of Hemp, Lychnis ioica, and some other plants, an embryo, or young plant, can be roduced without the influence of the pollen. These views have lately een confirmed. It has been supposed however by some, that in Hemp, here the stamens and pistil are generally on separate individuals, here may occasionally occur instances in which they are developed n the same plant. It is known that this takes place in other cases. hus, a specimen of Chamærops humilis, or European Fan-palm, in he Botanic Garden of Edinburgh, which had for upwards of twenty ears shown pistilliferous flowers only, exhibited, in 1847 and 1848, oth pistilliferous and staminiferous clusters, and produced perfect ruit without an artificial application of pollen. Again, in diœcious lants growing in the open air, the pollen may be carried from other

plants by the wind, and thus produce perfect seed. There are thus numerous sources of fallacy in Bernhardi's observations relative to Parthenogenesis, which require to be guarded against. Naudin has lately confirmed the opinions of Spallanzani and Bernhardi by experiment. He says that the female Hemp plant can produce perfect seeds without the action of pollen. Some, with Henslow, on the supposition of the correctness of Bernhardi's views, have thought that the case might be analagous to that of some Aphides, where one impregnation is sufficient to produce several generations. Mr. Smith and Radlkofer state that a female plant of Cœlebogyne, belonging to the natural order of Euphorbiaceæ, produces perfect seeds in the garden at Kew, without any apparent contact of pollen; and Gasparrini maintains, that in the case of the cultivated Fig, the seeds are the product of pistillate flowers only. Such cases, if proved, will modify the views entertained relative to the action of pollen. They are looked upon as cases of Parthenogenesis, or propagation without the action of pollen. They consist in the development of an individual from a cell with which no spermatozoid has come in contact. Can it be that, as in the case of some Cryptogamics, there are in these anomalous cases two kinds of cells present in the same organ, some with fertilizing matter, and others containing the rudiments of ovules, or of the embryo?

502. The subject of Embryogeny, or the development of the embryo in the seed, has attracted much attention of late, and numerous opinions have been advanced. There are discrepancies as to the contents of the ovule before impregnation; some maintaining that the cavity of the nucleus, or the embryo-sac alone, is developed before the pollen is applied; others, that besides it there is a utricle, or vesicle, in its interior, which forms the first embryonic cell. The tubes in contact with the ovule are by some said to be derived from the pollen alone; by others, partly from the ovule itself; and by a third set, partly from the conducting tissue of the style.

503. All modern physiologists believe in the formation of pollen-tubes, which were so ably demonstrated by Brown in Orchidaceæ and Asclepiadaceæ, and have subsequently been shown by Schleiden, Amici, Brongniart, Meyen, Mohl, Hofmeister, Tulasne, and others. These tubes, which vary in size, being often about $\frac{1}{2000}$ inch in diameter, may be easily traced in many instances, after the pollen has lain for a few hours on the stigma; for instance, in Crocus, Salvia, Colocasia odora, Gesnera, Œnothera, and Antirrhinum (fig. 434 *bis*). In some instances the emission of tubes commences almost immediately after the pollen has been applied to the stigma; in other cases, as in Mirabilis Jalapa, it takes from 24 to 36 hours. In the Larch, the tubes do not emerge for 35 days. When an ovary, style, and

re present, the tubes pass into the conducting tissue, while in
e of naked ovules, as in
and Cycadaceæ, the pollen
nto direct contact with the
. The length to which the
ubes extend is often very
n Cereus grandiflorus, Mor-
mated that the tubes, when
ched the ovary, extended as
50 times the diameter of the
rain; in Crinum amabile,
says that they reach 1875
e diameter of the grain; in
speciosa, 2719 times; in
us speciosus, 4489 times;
Colchicum autumnale, 9000
The length of time which the
tube takes to traverse the
ing tissues of the style in
erms varies. In some Gym-
s a year elapses before the
ches the embryo-sac.



434 *bis*

The extent to which the
enetrate, and the mode in
hey give rise to the embryo, have been matters of dispute.
aintain that the tubes formed by the intine proceed only
ain extent down the style before rupturing to discharge the
so that the influence of the latter is subsequently conveyed
vule by the conducting tissue, and thus causes the formation
bryo. Mirbel and Spach, from observations made on Grami-
Zea Mais, and on the Yew and other Coniferæ, were led to
this view. They believe that the tube does not reach the
at a primary utricle or vesicle (the first part of the embryo)
the embryo-sac, or cavity of the nucleus, before fertilization,
the fovilla is the means of determining the future develop-
an embryo in it. This utricle is attached to the embryo by
r process, or *suspensor*. These observations are opposed to
n's views, who, according to the opinions of their authors,
into the error of confounding a cell of the ovule with the
y of the pollen-tube. Giraud entertains the same opinion,
on an examination of the ovule of Tropæolum majus. In

is.—Portion of the stigma of Antirrhinum majus at the time of fecundation. *p s*, *p s*,
cells forming the papillæ. *t c*, *t c*, Deep elongated cylindrical cells forming the con-
ue. *g p*, Grains of pollen attached to the surface of the stigma, the extine having
ed, and the intine protruded in the form of tubes, *tp*, *tp*, which pierce the interstices
superficial stigmatic cells.

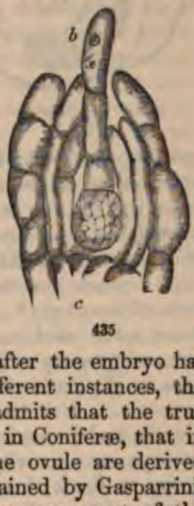
this plant he traces the formation of the amniotic or embryo-sac, [illegible] primary utricle or germinal vesicle of the embryo, before impregnation, the latter being at first distinct from the sac, but subsequently attached to it by a suspensor; the fovilla is brought into contact with the outer surface of the embryo-sac, and the first trace of the embryo appears in the formation of a spherical body at the inferior extremity of the primary utricle,—this spherical body resulting from a peculiar process of nutrition, determined by the dynamic influence of the fovilla. Giraud also observed a lengthening of the primary utricle and of its suspensor, so as to protrude through the apex of the embryo-sac, the nucleus, and the foramen, forming cells which partly communicate with the conducting tissue, and partly pass round the ovule within the carpellary cavity. By slight traction of this cellular process, the suspensor with the embryo may be drawn from the embryo-sac through the exostome.

505. Hartig thinks that in some cases where the pollen-tube cannot be traced directly downwards to the ovule, there is a series of cells, which, from their continuity, might be mistaken for it. In some recent observations on Campanula rotundifolia, Wilson appears to think that the pollen-tube is prolonged into the foramen of the ovule. Dickie has noticed, in Narthecium ossifragum, and Euphrasia officinalis and Odontites, a cellular process proceeding upwards from the ovule into the style, which he thinks may unite with the pollen-tube. Through Dr Dickie's kindness, I have had an opportunity of seeing these ovule tubes, which appear to end in shut extremities, and not to have a direct communication with the pollen-tubes. These tubes (less than $\frac{1}{5000}$ of an inch in diameter) have been traced by him from the interior of the embryo-sac. They are probably derived from the embryo itself, which, in its early state, may send out tubular prolongations similar to those of the spores of Cryptogamic plants. Tubular prolongations from the ovule were long ago noticed by Mirbel, and of late years by Griffith and Hartig. These authors, however, seem to differ from Dickie, in supposing that the tubes are derived from the embryo-sac, or some of the coverings of the ovule.

506. Another, or what may be called a third view of impregnation, is, that the pollen-tube does not stop short in the style, but proceeds as far as the foramen of the ovule, enters it, and is applied to the embryo-sac. In the case of the Mistleto, where there are no coverings of the ovule, and consequently no foramen, the pollen reaches the nucleus directly. Meyen, Amici, Mohl, Mülder, and Hofmeister, are in favour of this theory. Meyen states, that after the pollen-tube becomes united to the ovule in the form of a *cul de sac*, the process of absorption goes on so as to allow the fovilla to reach the embryo-sac. Immediately thereafter, a development of cells takes place in the form of a beaded prolongation or suspensor, at the extremity of which the

, in the form of a globular cell, is developed. The free comion between the pollen-tube and the embryo-sac ceases after a constriction takes place by the formation of a diagonal and the pollen-tube either shrivels or continues for some herent to the sac.

Amici also believes that the pollen-tube is applied to the sac mbryo. He observes in the nucleus a large cavity, which he d the embryonic vesicle (fig. 435 *c*). In Cucurbita Pepo and ceæ, he traces the tube to a certain depth into the nucleus, and ves that the granular contents of the tube, which are accumuthe extremity, are absorbed by the embryonic vesicle, so as impregnation. Cells are then produced in the vesicle, comat the base, *i.e.* opposite to the part he pollen-tube exerts its influence. The ecomes full of granular matter; it then a contraction in the middle, the lower oming appropriated to the embryo, and the true embryo-sac, while the upper uch plants as Orchis Morio and mascula, s upwards (fig. 435 *e*), forming a comfilament, composed of cells with fluid This filament traverses in an inverse the course followed by the pollen-tube, es into the interior of the placenta, being tinct from the pollen-tube, and probably d in some way with the nutrition of the



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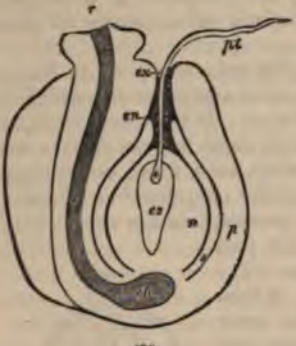
Sometimes the pollen-tube remains after the embryo has ed its cells. Hartig thinks, that, in different instances, the f impregnation is different. Thus he admits that the true ube comes into contact with the ovule in Coniferæ, that in uciferæ the tubes in connection with the ovule are derived e conducting tissue of the style, as maintained by Gasparrini, n certain Cupuliferæ, tubes proceed from some part of the self.

A fourth theory is, that the pollen-tube (fig. 436 *p t*), after the ovule, enters the foramen, *ex* and *en*, and then penetrates ryo-sac, *es*, or pushes the sac before it, becoming thus enclosed lection of it. This view was supported by Schleiden, Wydler, , and Deecke. Schleiden made a very elaborate series of obns on the embryo. According to him, the extremity of the ube did not enter the embryo-sac, but continued on the outit, pressing in the sac before it, and thus becoming surrounded

—Ovule of Orchis mascula, illustrating Amici's view of fertilization. *a*, Primine. *b*, *c*, Embryo. *e*, Confervoid filament which proceeds from the embryo towards the and is independent of the pollen-tube.

by a double layer of it. The end of the pollen-tube (fig. 436 *e*) formed the germinal vesicle, in the interior of which nuclei and cells were produced, which ultimately gave origin to the embryo, surrounded by the endosperm or albumen which results from the transformation of the contents of the embryo-sac. The end of the pollen-tube within the embryo-sac was then developed as the embryo, or a portion remained in the form of a suspensor, or suspensory filament, attached to the upper part of the sac.



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509. Wydler and others maintained that there was no indentation of the sac, but that the tube entered it directly. Schleiden thought that this may be true in certain cases where the embryo-sac becomes elongated upwards, and the membrane becomes absorbed so as to allow the pollen-tube to penetrate into the interior. Schleiden thus looked upon the embryo as a foreign body entering from without, and supported his views by cases of polyembryony in Coniferæ, Cycadaceæ, Mistleto, Onion, &c., where the plurality of embryos, according to him, depended on more than one pollen-tube having entered the foramen of the ovule.* Wilson adopted Schleiden's views, from observations made on Campanula rotundifolia. Tulasne, from examining the embryogeny of Veronica hederifolia, triphyllos, and præcox, concurs in Wydler's views relative to the pollen-tube entering the embryo-sac. Griffith, from his researches on Viscum, Santalum, Osyris, and Loranthus, concludes, that the pollen-tube penetrates the embryo-sac or cavity, and passes through it longitudinally; and he seems to think that, in some cases, the embryo proceeds from cells developed from the end of the tube. Klotszch states that pollen-tubes may be seen entering the embryo-sac in Lavatera tremestris, Tobacco, and some Orchidaceæ, after the pollen has lain from twenty-four to thirty-six hours on the stigma. Hofmeister admits that the pollen-tube, in some cases where the embryo-sac is very delicate, pushes it inwards to a certain extent.

Fig. 436.—Section of ovule to illustrate Schleiden's view of fertilization. *r*, Raphe. *c h*, Chalaza. *p*, Primine. *s*, Secundine. *e x*, Exostome. *e n*, Endostome. *n*, Nucleus. *e s*, Embryo-sac. *p t*, Pollen-tube. *e*, The embryo formed by the extremity of the pollen-tube.

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* Schleiden, einige Blicke auf die Entwickelungs-geschichte der Veget. Organism. See also Wydler, sur la formation de l'Embryon, Annales des Sciences Naturelles, 2d series, xi. 142. Schacht, Entwickelungs-geschichte des Pflanzen-Embryon. Amsterdam, 1850.

10. Those who object to Schleiden's views think that he mistook primary utricle, or germinal vesicle, which exists in the em- -sac before impregnation, for the end of the pollen-tube, and the cellular filament attaching this to the embryo-sac is totally pendent of the pollen-tube. Brown finds that, in the seed of ferous plants which have several embryos, there are semicylindrical uscles, three to six in number, which are arranged in a circle near ipex. In each of these is a distinct embryonal filament. These ents frequently ramify, each of the ramifications terminating in an yo. He believes that these corpuscles are not formed by the n-tubes, and that the fact of the ramifications giving rise to rudi- ary embryos is opposed to Schleiden's views. The corpuscles lie ant for at least twelve months before being developed. In a le plant belonging to Cycadaceæ, another polyembryonous order nts, Brown has noted the formation of corpuscles at a time when iale flowers were known to exist in the country. These cor- es may probably be considered as analogous to embryo-sacs, or yonal cavities, such as those in the Mistleto. Henfrey states in Conifers and Cycads the pollen-grains are applied immediately e micropyle of the ovule, which is a large opening; that they rse the cells of the nucleus, and are brought into contact with mbryo-sac. From the cells within this sac corpuscles become oped consisting of a large central cell, which, surrounded by four s, is accessible through a canal existing between them. The n-tube enters this canal, and impregnates the large central cell. the central cell the embryonic body, or pro-embryo, and the nsor, are produced. Each cell usually gives origin to four sus- rs with an embryo at the extremity of each, but only one of comes to maturity.

1. Schleiden and his supporters appear now to have given up views as to the end of the pollen-tube becoming the embryo. carefully observing some experiments made by Radlkofer,* iden has been led to believe that a germinal vesicle exists in the yo-sac before impregnation, and that this is what he mistook he extremity of the pollen-tube.

2. It will thus be seen that physiologists have been divided in views relative to this obscure subject; and when we consider ainuteness of the observations, and the high microscopic powers ired, it is not a matter of surprise that there should be numerous es of fallacy. All agree in the formation of pollen-tubes; these, rding to some, end in the cellular tissue of the style; according

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dlkofer, Die Befruchtungsprocess im Pflanzen-reiche. Leipzig, 1857. Also Ann. des es Naturelles, 4me serie, tom. v. 220.

to others, they reach the ovule; the influence of the fovilla is communicated to the ovule either directly or indirectly; the first cells o the embryo, some maintain, are formed by the end of the pollen-tube directly, while others say indirectly; and a third party consider them as the result of changes induced by the action of the fovilla.

513. The opinions which have been recently supported by Amici, Mohl, Karl Müller, Hofmeister, and Tulasne, are those which seem to rest on the best foundation, viz., that at the time of the opening of the flower the embryo-sac exists, and that, at its upper or micropylar end, one or more germ-cells or germinal vesicles are produced; that the pollen-tubes pass down the style to the ovary into the foramen of the ovule, and come into contact with the embryo-sac, either at its apex or a little below it; then an imbibition of fluids takes place; one of the germ-vesicles is fertilized, while the others disappear; and the fertilized cell enlarges, acquires an ovate, cylindrical, or clavate form, and is finally developed as the embryo with its suspensor.

514. The formation of the process called the suspensor is variously accounted for. Schleiden considers it as a part of the pollen-tube; Amici thinks that it is part of the embryo-sac prolonged upwards, forming a confervoid filament (fig. 435 *e*); Mohl, Mirbel, and Spach, maintain that the suspensor is produced from the germinal vesicle, and therefore intimately united to the embryo, which is developed from the lowest cells of that vesicle; Dickie thinks that the suspensor may be a cord-like process sent out from the cellular embryo, reaching a certain degree of development, and sometimes sending off tubular prolongations or filaments, as in Euphrasia and Orchidaceæ. The suspensor is usually directed to the apex of the nucleus or the micropyle, and it is sometimes of great length. In Draba verna (fig. 485, 2), Dickie says he observed in an embryo, $\frac{1}{40}$ of an inch long, a suspensor three times that length. In Gnetum, Griffith mentions a tortuous suspensor 3½ to 5 inches long, the whole seed being only one inch long.

515. Taking a comprehensive view of the whole subject, it may be said that the union of two kinds of cells appears to be necessary for fertilization. In Cryptogamic plants this has been traced, particularly in certain cases of conjugation; where the two cells come into contact, a tube is formed between them, and the contents of the one unites with those of the other, giving rise to a germinating body. In Phanerogamic plants, also, there are two cells with different contents —the pollen-grain with its granular fovilla, and the ovule with its mucilaginous fluid. These are brought into connection by means of the pollen-tube, formed from the intine, which either enters the embryo-sac, or comes into contact with it, the union taking place either directly by its extremity, or indirectly by cellular prolongations from the conducting tissue, or from the ovule. By this means the

he embryo is determined, which commences as a cellular
inal vesicle, in the interior of which other cells are sub-
ned in a definite order of succession.*

Production of Hybrids.—If the pollen of one species is
ertilize the ovules of another, the seed will often pro-
itermediate between the two parents. These are termed
ire analogous to mules in the animal kingdom. As a
hybrids can only be produced between plants which are
llied, as between the different species of the same genus.
it species of Heath, Fuchsia, Cereus, Rhododendron,
readily inoculate each other, and produce interme-
It is found, however, that many plants which seem to
lated do not hydridize. Thus, hybrids are not met
the Apple and Pear, between the Gooseberry and
between the Raspberry and Strawberry. The ovules of
nea, fertilized with the pollen of Fuchsia fulgens, pro-
iaving intermediate forms between these two species.
seedling plants closely resemble the one parent, and
r, but they all partake more or less of the characters of
examination of the foliage, conclusions may be drawn
ll be the character of the flower. Mr. Thwaites men-
which a seed produced two plants extremely different
and character; one partaking rather of the character
gens, and the other of Fuchsia coccinea.

case of hybridization, there appears to be a mixture of
ed from the pollen-grain and the ovule, just like the
o endochromes in flowerless plants; and the nature of
pends on the preponderance of the one or other. Some
that the pollen-grains require to be of the same form
i in order to admit of artificial union taking place; but
conjecture. It is, however, requisite that, for successful
the pollen should be in a state of full maturity, and
rfect. Hybrids perform the same functions as their
they do not perpetuate themselves by seed. They
igated by offsets or cuttings. If not absolutely sterile
isually become so in the course of the second or third

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to Embryology, see Schleiden's paper in Nova acta Academ. Cæsar. Leopold
ios.; Brown on the Fecundation of Orchidaceæ and Asclepiadaceæ, in the
Linnæan Society for 1833; Brongniart on the same subject, in Annales des
, 1st series, tom. xxiv., 1831; Meyen on the Act of Impregnation, translated
c Memoirs, vol. iii.; Amici sur la Fécondation des Orchidées, in Annales des
, 3d series, tom. vii.; Wilson on Tropæolum majus, and Hairs of Campanula,
Botany, vol. ii.; Giraud on Embryology, in the Transactions of the Edinburgh
and in the Annals of Natural History, vol. v.; and on the Ovule of Tropæo-
ansactions, vol. xix.; Henfrey and Dickie on Embryology, in the Annals of
1848; Griffith on the Ovule of Santalum, Osyris, &c., in Linnæan Transac-
Notulæ ad Plantas Asiaticas, Calcutta, 1847; Hofmeister, in Ann. des Sc.
5, xi. 375, 4th series, iii. 209; Tulasne, in Ann. des Sc. Nat., 3d series, xii. 21;
Sc. Nat., 3d series, ix. 33; Henfrey, Linn. Trans. xxi. 7.

generation. Herbert mentions instances of hybrid Narcissuses, from which he attempted in vain to obtain seed. The cause of this sterility has not been determined. Some have referred it to an alteration in the pollen. Hybrids may be fertilized, however, by the pollen taken from one of the parents, and then the offspring assumes the characters of that parent.

518. Hybrids are rarely produced naturally, as the stigma is more likely to be affected by the pollen of its own stamens than by that of other plants. In diœcious plants, however, this is not the case, and hence the reason, probably, of the numerous so-called species of Willows. Hybrids are constantly produced artificially, with the view of obtaining choice flowers and fruits, the plants being propagated afterwards by cuttings. In this way many beautiful Roses, Azaleas, Rhododendrons, Pansies, Cactuses, Pelargoniums, Fuchsias, Calceolarias, Narcissuses, &c., have been obtained. By this process of inoculation, and carefully selecting the parents, gardeners are enabled to increase the size of the flowers, to improve their colour, to render tender plants hardy, and to heighten the flavour of fruits. Herbert thinks, from what he saw in Amaryllides, that in hybrids the flowers and organs of reproduction partake of the characters of the female parent, while the foliage and habit, or the organs of vegetation, resemble the male.

519. This subject is important as connected with the origin and limitation of species. If, as some of the old authors believed, there were only a few species originally formed, and all the rest are the result of hybridization, there appears to be no limit to species, and no permanence in their characters. This, however, is not borne out by facts; the generally received opinion being, that types of all the species now in existence were originally placed on the globe, and that these have given origin to an offspring like themselves, capable of reproducing the species. Hybrids, on the other hand, are rare in a wild state, and they are seldom permanent and fertile. Even where they are so, there seems to be a tendency in the offspring to return to one or other of the original types from which they sprung.

6.—FRUIT, OR THE PISTIL ARRIVED AT MATURITY.

520. After fertilization, various changes take place in the parts of the flower. Those more immediately concerned in the process, the anther and stigma, rapidly wither and decay, while the filaments and style often remain for some time; the floral envelopes also become dry, the petals fall, and the sepals are either deciduous, or remain persistent in an altered form; the ovary becomes enlarged, forming the pericarp (περὶ, around, and καρπὸς, fruit); and the ovules are developed as the *seeds* containing the *embryo-plant*. The term *fruit*

is strictly applied to the mature pistil or ovary, with the seeds in its interior. But it often includes other parts of the flower, such as the bracts and floral envelopes. Thus, the fruit of the Hazel and Oak consists of the ovary and bracts and calyx combined; that of the Apple, Pear, and Gooseberry, of the ovary and calyx; and that of the Pine-apple, of the ovaries and floral envelopes of several flowers combined. Fruits formed by the ovaries alone, as the Plum and the Grape, seem to be more liable to drop off and suffer from unfavourable weather, than those which have the calyx entering into their composition, as the Gooseberry, the Melon, and the Apple.

521. In general, the fruit is not ripened unless fertilization has been effected; but cases occur in which the fruit swells, and becomes to all appearance perfect, while no seeds are produced. Thus, there are seedless Oranges, Grapes, and Pine-apples. When the seeds are abortive, it is common to see the fruit wither and not come to maturity; but in the case of Bananas, Plantains, and Bread-fruit, the non-development of seeds seems to lead to a larger growth, and a greater succulence of the fruit.

522. In order to comprehend the structure of the fruit, it is of great importance to study that of the ovary in the young state. It is in this way only that the changes occurring in the progress of growth can be determined. The fruit, like the ovary, may be formed of a single carpel, or of several. It may have one cell or cavity, then being *unilocular* (*unus*, one, and *loculus*, box or cavity); or many, *multilocular* (*multus*, many), &c. The number and nature of the divisions depend on the number of carpels, and the extent to which their edges are folded inwards. The appearances presented by the ovary do not, however, always remain permanent in the fruit. Great changes are observed to take place, not merely as regards the increased size of the ovary, its softening and hardening, but also in its internal structure, owing to the suppression, enlargement, or union of parts. In this way the parts of the fruit often become unsymmetrical, that is, not equal to, or some multiple of, the parts of the flower; and at times they are developed more in one direction than another, so as to assume an irregular appearance. In the Ash (fig. 437), an ovary with two cells, each containing an ovule attached to a central placenta, is changed into a unilocular fruit with one seed; one ovule, *l*, having become abortive, and the other, *g*, gradually extending until the septum is pushed to one side, becoming united to the walls of the cell,

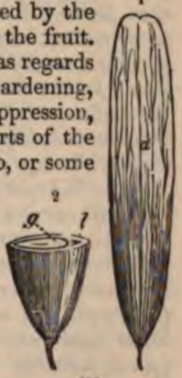

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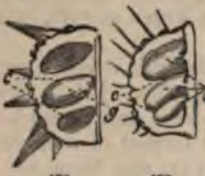
Fig. 437.—Samara, or Samaroid fruit of Fraxinus oxyphylla. 1. Entire, with its wing, *a*. 2. Lower portion cut transversely, to show that it consists of two loculaments; one of which, *l*, is abortive, and is reduced to a very small cavity, while the other is much enlarged, and filled with a seed, *g*.

and the placenta appearing to be parietal. In the Oak and Hazel, a ovary with three cells, and two ovules in each, changes into a one celled fruit with one seed. Similar changes take place in the Horse chestnut, in which the remains of the abortive ovules are often seen i the ripe fruit. In the Coco-nut, a trilocular and triovular ovary i changed into a one-celled, one-seeded fruit. This abortion may depen on the pressure caused by the development of certain ovules, or it ma proceed from the influence of the pollen not being communicated t all the ovules. Again, by the growth of the placenta, or the foldin inwards of parts of the ovary, divisions may take place in the frui which did not exist in the ovary. In Pretrea Zanguebarica, a one-celled ovary is changed into a four-celled fruit by the extension of th placenta. In Cathartocarpus Fistula (fig. 395), a one-celled ovary i changed into a fruit having each of its seeds in a separate cell, in consequence of spurious dissepiments being produced in a horizontal manner, from the inner wall of the ovary after fertilization. In Tribulus terrestris, each cell of the ovary (fig. 438) has slight projections, *c*, on its walls, interposed between the ovules, *o*, which, when the fruit is ripe, are seen to have formed distinct transverse divisions (fig. 439 *c*), or spurious dissepiments, separating the seeds, *g*. In Astragalus, the folding of the dorsal suture inwards converts a one-celled ovary into a two-celled fruit.



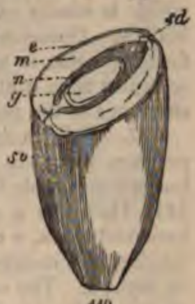
439 438

523. The development of cellular or pulpy matter frequently makes great changes in the fruit, and renders it difficult to discover its formation. In the Strawberry, the axis becomes succulent, and bears the carpels on its convex surface; in the Rose, there is a fleshy lining of the calyx (sometimes called a disk), which bears the carpels on its concave surface. In the Gooseberry, Grape, Guava, Tomato, and Pomegranate, the seeds nestle in pulp formed apparently by the placentas. In the Orange, the pulpy matter surrounding the seeds is formed by succulent cells, which are produced from the inner lining of the pericarp.

524. The pistil, in its simplest state, consists of a carpel or folded leaf, with ovules at its margin; and the same thing will be found in the fruit, where the pericarp, as in the Bean (fig. 440), represents the carpellary leaf, and the seeds correspond to the ovules. The pericarp consists usually of three layers; the external (fig. 440 *e*), or *epicarp* (ἐπί, upon, or on the outside, καρπὸς, fruit), corresponding to the lower epidermis of the leaf; the middle (fig. 440 *m*), or *mesocarp* (μέσος, middle), representing the parenchyma of the leaf; and the internal (fig. 440 *n*), or *endocarp* (ἔνδον, within), equivalent to the

Fig. 438.—Cell or loculament of the ovary of Tribulus terrestris, cut vertically, to show the commencement of the projections, *c*, from the paries, which are interposed between the ovules, *o*.
Fig. 439.—The same in a mature state, showing the transverse partitions, *c*, dividing the frui into cavities, in one of which a seed, *g*, is left.

upper epidermis of the leaf, or the epithelium of the ovary. In some plants, as Colutea arborescens, the pericarp retains its leaf-like appearance, but in most cases it becomes altered both in consistence and in colour. Sometimes the three parts become blended together, as in the Nut; at other times, as in the Peach, they remain separable. In the latter fruit, the epicarp is thickened by the addition of cells, and can be taken off in the form of what is called the skin; the mesocarp becomes much developed, forming the flesh or pulp, and hence has sometimes been called *sarcocarp* (σάρξ, flesh), while the endocarp becomes hardened by the production of woody cells, and forms the *stone* or *putamen* (*putamen*, a shell), immediately covering the kernel or the seed. The same arrangement is seen in the fruit of the Cherry, Apricot, and Plum. In these cases, the mesocarp is the part of the fruit which is eaten. In the Almond, on the other hand, the seed is used as food, while the shell or endocarp, with its leathery covering or mesocarp, and its greenish epicarp, are rejected. The pulpy matter found in the interior of fruits, such as the Gooseberry, Grape, and Cathartocarpus Fistula (fig. 395), is formed from the placentas, and must not be confounded with the sarcocarp.



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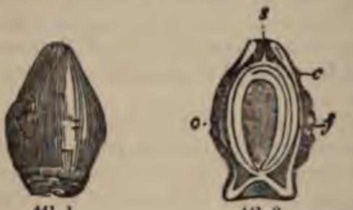
525. In the Date, the epicarp is the outer brownish skin, the pulpy matter is the mesocarp or sarcocarp, and the thin papery-like lining is the endocarp covering the hard seed. In the Pear and Apple, the outer skin or epicarp is composed of the epidermis of the calyx, combined with the ovary; the fleshy portion is the mesocarp, formed by the cellular portion of the calyx and ovary; while the scaly layer, forming the walls of the seed-bearing cavities in the centre, is the endocarp. In the Medlar (fig. 472), the endocarp becomes of a stony hardness. In the Melon, the epicarp and endocarp are very thin, while the mesocarp forms the bulk of the fruit, varying in its texture and taste in the external and internal part. The rind of the Orange consists of epicarp and mesocarp, while the endocarp forms partitions in the interior, filled with pulpy cells.

526. Thus, while normally the divisions of the fruit ought to indicate the number of the carpels composing it, and these carpels should each have three layers forming the walls, it is found that frequently the divisions of a multilocular fruit are atrophied or absorbed, in whole or in part, and the layers become confounded together, so that they appear to be one. Again, in fruits formed of several carpels, the

Fig. 440.—Lower portion of the carpel or legume of the Bean, Faba sativa, cut transversely, to show the structure of the pericarp. *e*, Epicarp, or external epidermis *m*, Mesocarp. *n*, Endocarp. *s d*, Dorsal suture. *s v*, Ventral suture. *g*, A seed situated at the upper part of the section, and cut also transversely.

endocarp and mesocarp are occasionally so much developed as to leave the epicarp only on the free dorsal face of the fruit, forming a covering which is wholly external, as in the Castor-oil plant, Euphorbia, and Mallow. Occasionally, the endocarp remains attached to the centre, forming cells, in which the seeds are placed, while the outer layer separates from it at certain points, and leaves a row of cavities in the substance of the pericarp itself.

527. While in many fruits the calyx becomes incorporated with the pericarp, there are others in which it is closely applied to the ovary, but still separable from it. Thus, in the fruit of Mirabilis Jalapa (fig. 441, 1), when a section is made longitudinally (fig. 441, 2), the hardened calyx, *c c*, is observed distinct from the fruit, *f*, which is in this instance incorporated with the seed, but at once distinguished by its style, *s*. The same thing occurs in Spinacia or Spinach. Again, in the Yew (fig. 442), there is an external succulent covering, it is formed by modified bracts, which here occupy the place of a pericarp, and surround the seed, *g*, which is naked, inasmuch as it is not contained in a true ovary with a style and stigma.



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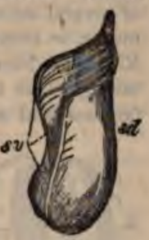
528. The part of the pericarp attached to the peduncle is called its *base*, and the part where the style or stigma existed is the *apex*. This latter is not always the mathematical apex. In Alchemilla, Labiatæ, and Boraginaceæ, it is at the base or side (figs. 400, 401, 402). The style sometimes remains in a hardened form, rendering the fruit *apiculate;* at other times it falls off, leaving only traces of its existence. The presence of the style or stigma serves to distinguish certain single-seeded pericarps from seeds.

529. As in the case of the carpel, so in the mature ovary formed of it, the edges unite towards the axis, and constitute the ventral suture (fig. 443 *s v*), while the back, corresponding with the midrib, is the

Fig. 441.—Fruit of Mirabilis Jalapa. 1. Entire. 2. Cut longitudinally, to show its [illegible]tion. *c c*, Lower part of calyx hardened, and forming an outer envelope. *f*, The tru covered by the calyx. The integuments of the fruit are incorporated with those of th which has been also cut. The fruit is distinguished by the remains of the style, *s*, at the a or summit.

Fig. 442.—Fruit of Taxus baccata, the Yew. *b*, Imbricated bracts at its base. *i c*, envelope taking the place of the pericarp. This envelope covers the seed, *g*, partially, its apex naked.

443 *s d*). The inner suture in some fruits formed
as the Apricot and Bladder senna,
istinct furrow or depression, conse-
ng inwards of the carpellary edges;
the outer or dorsal suture is also
inctly visible. When the fruit con-
ıature carpels, all meeting in the
together, then the dorsal suture is
ılly; but in cases where the placen-
r free central, then the edges of the
eing near the surface, may present
marks of the ventral sutures.



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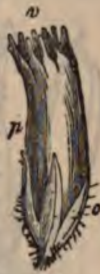
ɛ sutures are formed, there are usually two bundles
ssue (fig. 443), one on each edge. The edges of the
o intimately united, as not to give way when the fruit
ase it is called *indehiscent* (*in*, used in the sense of
open), as in the Acorn and Nut; at other
ɔens between the two vascular bundles,
ral or dorsal suture, so as to allow the
nd then it is *dehiscent* (*dehisco*, I open).
the pericarp becomes divided into dif-
h are denominated *valves*, the fruit being
ular, or *multivalvular*, &c., according as
, or many valves. These valves separate
or partially. In the latter case, the divi-
the form of teeth at the apex of the fruit,
ing *apicilar*, as in Caryophyllaceæ (fig.
ial slits of the ventral suture, when the
ee at the apex, as in Saxifrages.



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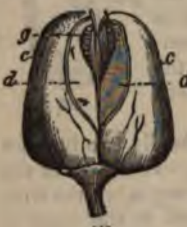
nt Fruits are either dry, as the Nut, or fleshy, as
pple. They may be formed of one or several car-
former case they usually contain only a single seed,
e so incorporated with the pericarp as to appear to
fruits are called *pseudo-spermous* (ψευδὴς, false, and
false-seeded, and are well seen in the grain of Wheat.
presence of the style or stigma determines their true

Fruits, when composed of single carpels, may open
ure only, as in the follicles of Pæony; by the dorsal
y both together, as in the legume of the Pea and

rpel of Helleborus fœtidus after dehiscence. *s d*, Dorsal suture. *s v*,
rpel, when mature, opens on the ventral suture, and forms the fruit

dry seed-vessel of Cerastium triviale after dehiscence, c, Persistent
ding at the apex, *v*, into ten teeth, which indicate the summits of as
w.

Bean; in which cases the dehiscence is called *sutural*. When composed of several united carpels, the valves may separate through the dissepiments, so that the fruit will be resolved into its original carpels, as in Rhododendron, Colchicum, &c. This dehiscence, in consequence of taking place through the lamellæ of the septum, is called *septicidal* (*septum* and *cædo*, I cut) (figs. 445, 446). The valves may separate from their commissure, or central line of union, carrying the placentæ with them, or they may leave the latter in the centre, so as to form



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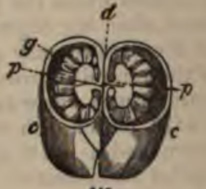

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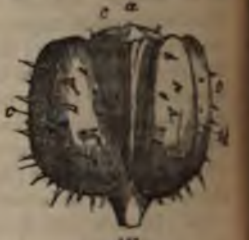

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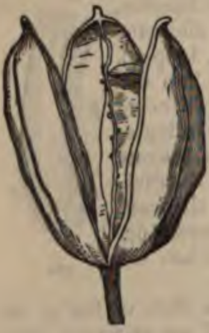

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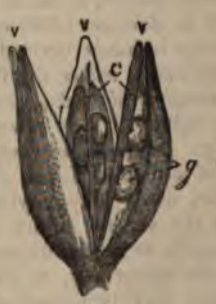

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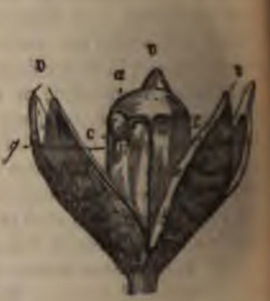

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Fig. 445.—Capsule of Digitalis purpurea at the moment of dehiscence, when the two carpels *c c*, separate by division of the septum, *d d*, so as to have the appearance of distinct carpels. At the apex are seen the seeds, *g*.

Fig. 446.—Inferior portion of the same capsule cut transversely, to show the formation of the septum, *d*, formed by the two inner faces of the carpels, *c c*. *p p*, Placentaries reflected and projecting into the anterior of the cavities. *g*, Seeds.

Fig. 447.—Capsule (*tricoccous regma*) of Ricinus communis, Castor-oil plant, at the moment of dehiscence. The three carpels or cocci, *c c c*, are separated from the axis, *a*, by which they were at first united (see fig. 453), and which remains in a columnar form. These cocci begin to open by their dorsal suture, *s*, *d*.

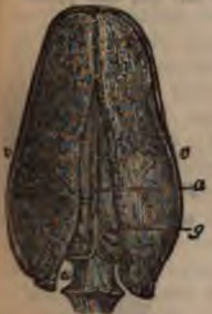
Fig. 448.—Capsule of Iris opening by loculicidal dehiscence.

Fig. 449.—Capsule of Hibiscus esculentus, showing also loculicidal dehiscence. *v v v*, Valves of the seed-vessel. *c*, Septum or partition. *g*, Seeds.

Fig. 450.—Capsule of Cedrela angustifolia, the valves of which, *v v v*, separate from the septa *c*, *c*, by septifragal dehiscence. The separation takes place from above downwards, in such a manner that the axis, *a*, remains in the centre, with five projecting angles, corresponding to the septa. *g*, The seeds contained in the loculaments.

with the axis a column of a cylindrical, conical, or prismatic shape, which has received the designation of *columella* (fig. 447 *c*). The union between the edges of the carpels may be persistent, and they may dehisce by the dorsal suture, or through the back of the loculaments, as in the Lily and Iris (fig. 448). In this case the valves are formed by the halves of the cells, and the septa either remain united to the axis, or they separate from it, carrying the placentas with them (fig. 449), or leaving them in the centre. This dehiscence is *loculicidal* (*loculus*, cell, and *cædo*, I cut). Sometimes the fruit opens by the dorsal suture, and at the same time the valves or walls of the ovaries separate from the septa (fig. 450), leaving them attached to the centre, as in Datura. This is called *septifragal* dehiscence (*septum* and *frango*, I break), and may be looked upon as a modification of the loculicidal. The separation of the valves takes place either from above downwards (fig. 450), or from below upwards (fig. 451).

533. Sometimes the axis is prolonged as far as the base of the styles, as in the Mallow (fig. 452), and Castor-oil plant (fig. 453), the carpels being united to it by their faces, and separating from it without opening. In the Umbelliferæ (fig. 454), the two carpels separate from the lower part of the axis, and remain attached to a prolongation of it, called a *carpophore* (καρπὸς, fruit, and φορέω, I bear), or *podocarp* (ποῦς, foot, and καρπός, fruit), which splits into two (fig. 454 *a*), and suspends them. Hence the name *cremocarp* (κρεμάω,



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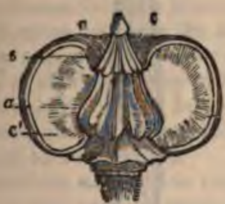

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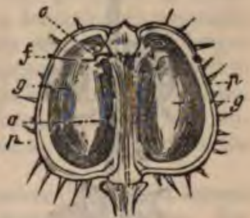

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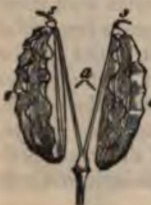
Fig. 451.—Capsule of Swietenia Mahagoni, opening by valves from below upwards. The letters have the same signification as in fig. 450.

Fig. 452.—Fruit of Malva rotundifolia, with half the carpels comprising it removed, to show the axis, *a*, to which they are attached. This axis ends at the point where the style, *s*, is produced. *c c*, The carpels which are left attached to the axis, around which they are arranged in a verticillate manner. The lateral surface of the two carpels in front, *c'*, is exposed.

Fig. 453.—Tricoccous capsule of Ricinus communis, Castor-oil plant, cut vertically, to show the axis, *a*, prolonged between the carpels, and terminating by small cords or funiculi, *f*, which project into the loculaments, and are attached to seeds. *g g*, Seeds exposed, each surmounted by a fleshy caruncula, *c*. *p p*, Pericarp.

I suspend), applied to this fruit. In Geraniaceæ, the axis is longed beyond the carpels, forming a carpophore, to which the s are attached, and the pericarps separate from below upwards, b dehiscing by their dorsal suture (fig. 455). Carpels of this kin called *cocci* (κόκκος, seed, berry), and the fruit is said to be *tricoc* &c., according to the number of separate carpels. In the ca many Euphorbiaceæ, as Hura crepitans, the separate with great force and elasticity, the being called *dissilient* (*dissilio*, I burst).



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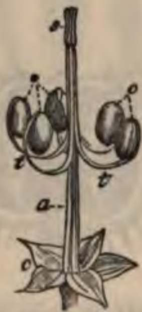
534. In the Siliqua, or fruit of Crucifera Wallflower, (fig. 456), the valves separate the base of the fruit, leaving a central *rep* or frame, *r*. The replum is considered as b formed by parietal placentas, which remain atta to the fibro-vascular line of the suture, the va giving way on either side of the suture. In chidaceæ (fig. 457), the pericarp, when ripe, separates into t valves, by giving way only on the margins within the sutures, w the placentas are united; and when the valves fall off, the place



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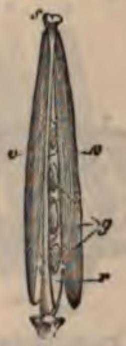

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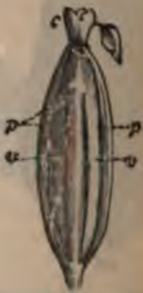

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are left in the form of three arched repla, or frames, to which seeds are attached. In the case of a free central placenta, when valves separate, it is sometimes difficult to tell whether the dehisc

Fig. 454.—Fruit or cremocarp of Prangos uloptera, an umbelliferous plant. The mericarps, or achænia, *c c*, separate from the axis, *a*, and are each suspended by a carp *s s*, Persistent styles with swollen bases, forming an epigynous disk.

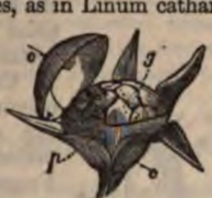
Fig. 455.—Fruit or mature carpel of Geranium sanguineum. *c*, Persistent calyx. prolonged as a beak. *t t*, The styles, at first united to the beak, and afterwards separating below upwards, along with the carpels, *o o*, which dehisce by their dorsal suture. The fruit is sometimes called gynobasic.

Fig. 456.—Siliqua of Cheiranthus Cheiri, Wallflower, dehiscing by two valves, separate from a frame or replum, *r*. *g*, Seeds arranged on either margin. *s*, Two-lobed

Fig. 457.—Capsule of Orchis maculata at the period of dehiscence. *c*, Remains of the the calyx crowning the fruit. *v v*, Segments of the pericarp which are detached in the valves. *p p*, Arched repla or placentas which remain persistent, and bear the seeds

is septicidal or loculicidal, inasmuch as there are no dissepiments, and the placentas and seeds form a column in the axis. Their number, as well as their alternation or opposition, as compared with the sepals, will aid in determining whether the valves are the entire carpellary leaves, as in septicidal dehiscence, or only halves united, as in loculicidal. In some instances, as in Linum catharticum, the fruit opens first by loculicidal dehiscence, and afterwards the carpels separate in a septicidal manner.

535. Another mode in which fruits open is transversely, the dehiscence in this case being called *circumscissile* (*circum*, around, and *scindo*, I cut). In such cases, the fruit or seed-vessel may be supposed to be formed by a number of articulated leaves like those of the Orange, the division taking place where the laminæ join the petioles. In this dehiscence, the upper part of the united valves falls off in the form of a lid or operculum, as in Anagallis (fig. 458), and in Hyoscyamus (fig. 459), and hence the fruit is often denominated *operculate* (*operculum*, a lid). In some instances the axis seems to be prolonged in the form of a hollow cup, and the valves appear as leaves united to it by articulation, similar to what occurs in the calyx of Eschscholtzia. In Lecythis, or the Monkey-pot, and in Couratari, the calyx is adherent to the seed-vessel, and the lid is formed at the place where the tube of the calyx ceases to be adherent.



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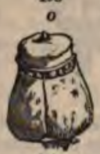

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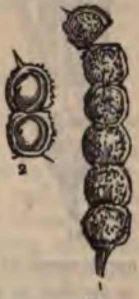

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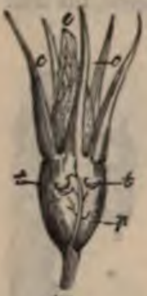
536. Transverse divisions take place occasionally in fruits formed by a single carpel, as in the pods of some leguminous plants. Examples are met with in Ornithopus, Hedysarum, (fig. 460), Coronilla, &c., in which each seed is contained in a separate division, the partitions being formed by the folding in of the sides of the pericarp, and distinct separations taking place at these partitions, by what has been termed *solubility*. Some look upon these pods as formed by pinnate leaves folded, and the divisions as indicating the points where

Fig. 458.—Pyxidium or capsule of Anagallis arvensis, opening by circumscissile dehiscence. c, Persistent calyx. p, Pericarp divided into two, the upper part, o, separating in the form of a lid or operculum. On the capsule are seen three lines passing from the base to the apex, and marking the true valves. g, Seeds forming a globular mass round a central placenta.

Fig. 459.—Operculate capsule or Pyxidium of Hyoscyamus niger, Henbane. o, Operculum or lid separating and allowing the seeds to appear.

Fig. 460.—Lomentaceous legume or lomentum of Hedysarum coronarium. 1. Entire, the upper division being nearly detached from the rest. 2. Two of the joints cut longitudinally to show the spurious loculaments, each containing a seed. This seed-vessel divides into separate single-seeded portions by solubility

the different pairs of pinnæ are united. Others do not a explanation, but regard the legume or pod as formed by the midrib or petiole, and the pinnæ as represented by the se hiscence may also be effected by partial openings in the called *pores*, which are situated either at the apex, base, or the Poppy (fig. 409), the ope place by numerous pores peltate processes bearing the In Campanulas, there are openings towards the middl (fig. 461 *t*), which pierce pericarp and the adherent c Frogsmouth (fig. 462) or Sn the pericarp gives way a fixed points, forming two orifices, one of which corre the upper carpel, and the ot lower. These orifices have appearance at the margins, which has given rise to the name as applied to this mode of dehiscence.



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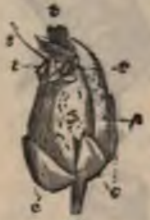

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537. **Carpology.**—Much has been done of late in the stu*pology* (καρπὸς, fruit, and λόγος, discourse), or the formatic fruit; but much still remains to be done ere the terminolo department is complete. Many classifications of fruits h given, but they are confessedly imperfect, and unfortunat confusion has arisen in consequence of the same names ha applied to different kinds of fruit. In many cases, theref necessary to give a description of a fruit in place of using term. There are, however, some names in general use, a which have been carefully defined, to which it is necessary attention.

538. Fruits may be formed by one flower, or they ma product of several flowers combined. In the former case, either *apocarpous* (ἀπὸ, separate, and καρπὸς, fruit), or *dia* (διαλύω, I dissolve, or separate), that is, composed of one m pel, or of several separate free carpels; or *syncarpous* (σύν, t that is, composed of several carpels, more or less complete These different kinds of fruits may be *indehiscent* (not op *dehiscent* (opening). When the fruit is composed of the c

Fig. 461.—Capsule of Campanula persicifolia, opening by holes or pores, *t t*, abo *c*, Persistent calyx, incorporated below with the pericarp, *p*, and separating ab acute segments, in the midst of which is seen the withered and plaited corolla in induviæ, *c*. The holes perforate the walls of the pericarp and the calyx.

Fig. 462.—Capsule of Antirrhinum majus, Frogsmouth, after dehiscence. *c c*, Per *p*, Pericarp perforated near the summit by three holes, *t t*, two of which correspond loculaments, and one to the other. The apex of the capsule is acuminated by the r persistent style, *s*.

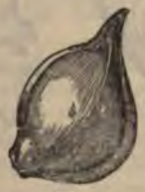
several flowers united, it is usual to find the bracts and floral envelopes also joined with them, so as to form one mass; hence such fruits are called *multiple* or *anthocarpous* (ἄνθος, flower, and καρπὸς, fruit). The term *simple* is perhaps properly applied to fruits, which are formed by the ovary of a single flower, whether they are composed of one or several carpels, and whether these carpels are separate or combined. Simple fruits are hence sometimes denominated *Monogynœcial* (μόνος, one, γυνὴ, pistil, and οἰκιον, habitation), as being formed by one gycœncium, while multiple fruits are called *polygynœcial* (πολὺς, many) as being formed by many gynœcia.

Fruits which are the Produce of a Single Flower.

539. **Apocarpous Fruits.**—These fruits are formed out of one or several free carpels. They are either *dry* or *succulent;* the pericarp, in the former instance, remaining more or less foliaceous in its structure, and sometimes becoming incorporated with the seed; in the latter, becoming thick and fleshy, or pulpy. Some of these do not open when ripe, but fall entire, the pericarp either decaying, and thus allowing the seeds ultimately to escape, as is common in fleshy fruits, or remaining united to the seed, and being ruptured irregularly when the young plant begins to grow; such fruits are *indehiscent.* Other apocarpous fruits, when mature, open spontaneously to discharge the seeds, and are *dehiscent.*

540. **Indehiscent Apocarpous Fruits,** when formed of a single mature carpel, frequently contain only one seed, or are *monospermous* (μόνος, one, and σπέρμα, seed). In some instances there may have been only one ovule originally, in others two, one of which has become abortive.

541. The *Achænium* (α, privative, and χαίνω, I open), is a dry monospermous fruit, the pericarp of which is closely applied to the seed, but separable from it (fig. 463). It may be *solitary,* forming a single fruit, as in the Cashew (fig. 227 *a*), where it is supported on a fleshy peduncle, *p;* or *aggregate,* as in Ranunculus (fig. 464), where several achænia are placed on a common elevated receptacle. In the Strawberry, the achænia are placed on a convex succulent receptacle. In the Rose, they are supported on a concave receptacle, covered by the calycine tube (fig.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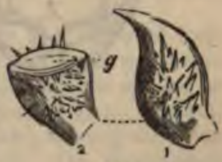

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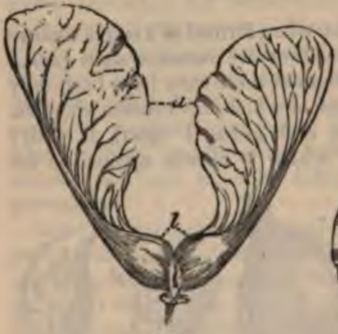
Fig. 463.—Achænium or indehiscent monosperous carpel from the pistil of a Ranunculus.

Fig. 464.—1. Similar achænium, with rough points on the pericarp, from the pistil of Ranunculus muricatus. 2. Achænium cut transversely to show the seed, *g*, not adherent to the parietes.

270), and in the Fig, they are placed inside the hollow peduncle or receptacle (fig. 246), which ultimately forms what is commonly called the fruit. In the Rose, the aggregate achænia, with their general covering, are sometimes collectively called *Cynarrhodum* (κυὼν, a dog, and ῥόδον, a rose, seen in the dog-rose). It will thus be remarked, that what in common language are called the seeds of the Strawberry, Rose, and Fig, are in reality carpels, which are distinguished from seeds by the presence of styles and stigmas. The styles occasionally remain attached to the achænia, in the form of feathery appendages, as in Clematis, where they are called *caudate* (*cauda*, a tail).

542. In Compositæ, the fruit which is sometimes called *Cypsela* (κυψέλη, a box), when ripe, is an achænium united with the tube of the calyx (fig. 279 *t*). The limb of the calyx in the Compositæ sometimes becomes pappose, and remains attached to the fruit, as in Dandelion, Thistles, &c. (fig. 279 *l*). When the pericarp is thin, and appears like a bladder surrounding the seed, the achænium becomes a *Utricle*, as in Amaranthaceæ. This name is often given to fruits which differ from the achænium, in being composed of more than one carpel. When the pericarp is extended in the form of a winged appendage, a *Samara* (*samera*, seed of Elm) or *samaroid achænium* is produced, as in the Ash (fig. 437), common Sycamore (fig. 465), and Hiræa (fig. 466). In these cases, there are usually two achænia united, one of which, however, as in Fraxinus oxyphylla (fig. 437), may be



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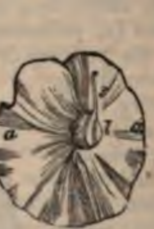

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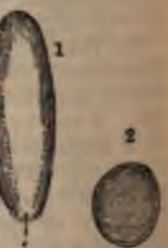

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Fig. 465.—Seed-vessel of Acer Pseudo-platanus, composed of two samaras or winged monospermous carpels united. *a*, Upper part forming a dorsal wing. *l*, Lower portion corresponding to the loculaments.

Fig. 466.—Samara taken from the fruit of Hiræa. *s*, Persistent style. *l*, Part corresponding to the loculament. *a a*, Marginal wing or ala.

Fig 467.—Caryopsis of Secale cereale, Rye. 1. Entire. 2. Cut transversely to show the seed adherent to the parietes of the pericarp.

abortive. The Wing (fig. 465 *a*) is formed by the carpel, and is either *dorsal*, *i.e.* a prolongation from the median vein (fig. 465 *a*), or *marginal*, that is, formed by the lateral veins (fig. 466 *a*). It surrounds the fruit longitudinally in the Elm. When the pericarp becomes so incorporated with the seed as to be inseparable from it, as in Grains of Wheat, Maize, Rye (fig. 467), and other grasses, then the name *Caryopsis* (καρύα, a nut, and ὄψις, appearance) is given.

543. There are some fruits which consist of two or more achænia, at first united together, but which separate when ripe. Of this nature is the fruit of the Tropæolum or Indian Cress, also that of Labiatæ, and Boraginaceæ, which is formed of four achænia attached to the axis (fig. 402), whence the common style appears to proceed. Some of these are occasionally abortive. In the ripe state the pericarp separates from the seed in these cases; and thus there is a transition from indehiscent achænia to single-seeded dehiscent pericarps. So also the *Cremocarp* (κρεμάω, to suspend), or the fruit of Umbelliferæ (fig. 454), which is composed of two achænia united by a commissure to a common axis or *carpophore* (καρπὸς, fruit, and φορεω, I bear), from which they are suspended at maturity. It is sometimes denominated *diachænium* (δὶς, twice), from the union of two achænia, which in this instance receive the name of *mericarps* (μέρος, part), or *hemicarps* (ἥμισυς, half, and καρπὸς, fruit).

544. *The Nut or Glans.* This is a one-celled fruit with a hardened pericarp, surrounded by bracts at the base, and, when mature, containing only one seed. In the young state, the ovary contains two or more ovules, but only one comes to maturity. It is illustrated by the fruit of the Hazel and Chestnut, which are covered by leafy appendages, in the form of a *husk*, and by the Acorn, in which the leaves or bracts are united so as to form a *cupula* or *cup* (fig. 257). The parts of the pericarp of the Nut are united so as to appear one. In Sagus, or the Sago Palm, it is covered by peculiar closely applied scales, giving the appearance of a cone.

545. *The Drupe* (*drupæ*, unripe olives). This is a succulent fruit covered by a pericarp, consisting of epicarp, mesocarp, and endocarp; and when mature, containing a single seed. This term is applied to such fruits as the Cherry, Peach, Plum, Apricot, Mango, Walnut, Nutmeg, and Date. The endocarp is usually hard, forming the stone of the fruit, which encloses the kernel or seed. The mesocarp is generally pulpy and succulent, so as to be truly a *sarcocarp* (Peach), but it is sometimes of a tough texture, as in the Almond, and at other times more or less fibrous. There is thus a transition from the Drupe to the Nut. Moreover, in the Almond, there are often two ovules formed, only one of which comes to perfection. In the Walnut, the endocarp, which is easily separable into two, forms prolongations which enter into the interior, and cause a remarkable division in the seed.

It has been sometimes called *Tryma.* In the Raspberry and Bramble several small drupes or *drupels* are aggregated so as to constitute a *Etærio* (ἑταῖρος, a companion).

546. **Dehiscent Apocarpous Fruits.**—These open in various ways and usually contain more than one seed, being either few-seeded *oligospermous* (ὀλίγος, few, and σπέρμα, a seed), or many-seeded, *polyspermous* (πολὺς, many).

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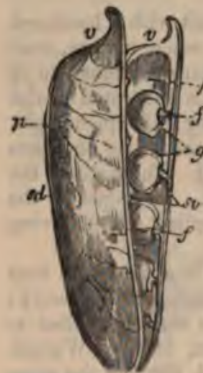
547. *Follicle* (*folliculus*, a little bag). This is a matur carpel, containing several seeds, and opening by the ventra suture (figs. 443, 468). It is rare to meet with a solitar follicle forming the fruit. There are usually several aggregated together, either in a circular manner on a shorten receptacle, as in Hellebore, Aconite, Delphinium, and Asclepiadaceæ; or in a spiral manner on an elongated receptacl as in Magnolias, Banksias, and Liriodendron (fig. 30 Occasionally, as in Magnolia grandiflora, some of the follicle open by the dorsal suture.

548. *The Legume or Pod* (*legumen*, pulse) is a solitary, simple, mature carpel, dehiscin by the ventral and dorsal suture, and bearing seeds on the former. It characterizes leguminous plants, and is seen in the Bean and Pea (fig. 469). In the Bladder-senna (fig. 470) it retains its leaf-like appearance, and forms an inflated legume. In some Leguminosæ, as Arachis, the fruit must be considered a legume, although it does not dehisce. In place of opening at the sutures, some legumes are contracted at intervals, so



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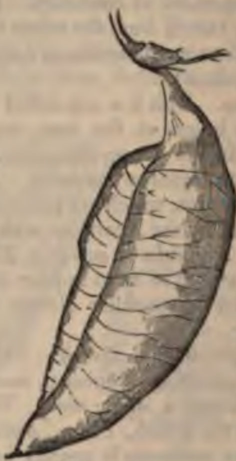
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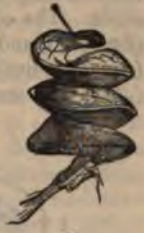
Fig. 468.—Follicle or dehiscent many-seeded carpel of Aquilegia vulgaris, Columbine. The follicle dehisces by the ventral suture only.

Fig. 469.—Legume of Pisum sativum, common Pea, opened. It is formed by a single carpel, and dehisces by the ventral and dorsal suture. *v v*, Valves formed by the two parts of the pericarp. *p*, The epicarp or external layer of the pericarp. *p'*, Endocarp or internal layer. Between these the mesocarp is situated. *g*, Seeds placed one over the other, attached to the placenta by short funiculi or cords, *f f*. The placenta forms a narrow line along the ventral suture, *s v*. *s d*, The dorsal suture corresponding to the midrib of the carpellary leaf.

Fig. 470.—Legume of Bladder-senna (*Colutea arborescens*), showing an inflated, foliaceous pericarp.

as to include each seed in a separate cell, and when ripe, the different divisions of the pod separate from each other. This constitutes the *Lomentum* (*lomentum*, bean-meal), or *lomentaceous legume* of Hedysarum coronarium (fig. 460), Coronillas, Ornithopus, &c. In Medicago, the legume is twisted like a snail (fig. 471), and in Cæsalpinia coriaria, or Divi-divi, it is vermiform or curved like a worm; in Carmichaelia, the valves give way close to the suture, and separate from it, leaving a division.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549. **Syncarpous Fruits** are formed by several carpels, which are so united together as to appear one in their mature state. These fruits are either dry or succulent; in the former case, being usually dehiscent, in the latter, indehiscent.

550. **Indehiscent Syncarpous Fruits.**—*The Berry* (*bacca*) is a succulent fruit, in which the seeds are immersed in a pulpy mass, formed by the placentas. The name is usually given to such fruits as the Gooseberry and Currant, in which the calyx is adherent to the ovary, and the placentas are parietal, the seeds being ultimately detached from the placenta, and lying loose in the pulp. Others have applied it also to those in which the ovary is free, as in the Grape, Potato, and Ardisia, and the placentas central or free central. The latter might be separated under the name *Uva* (grape). In general, the name of *baccate* or *berried* is applied to all pulpy fruits. In the Pomegranate there is a peculiar baccate many-celled fruit, having a tough rind formed by the calyx, enclosing two rows of carpels placed above each other. The seeds are immersed in pulp, and are attached irregularly to the parietes, base, and centre. The fruit has been called *Balausta* (*balaustium*, flower of pomegranate), and the tough rind is called *malicorium* (a name applied to it by Pliny).

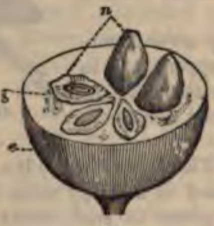
551. The *Pepo* or *Peponida* (πέπων, a pumpkin), is illustrated by the fruit of the Gourd, Melon, and other Cucurbitaceæ, where the calyx is adherent, the rind is thick and fleshy, and there are three or more seed-bearing parietal placentas, either surrounding a central cavity, or sending prolongations inwards. The fruit of the Papaw resembles the Pepo, but the ovary is not adherent to the calyx.

552. The *Hesperidium* (golden fruit in the garden of Hesperides) is the name given to the fruit of the Orange, &c., in which the epicarp and mesocarp form a separable rind, and the endocarp sends prolongations inwards, forming triangular divisions, in which pulpy cells are developed so as to surround the seeds which are attached to the inner angle. Both Pepo and Hesperidium may be considered as modifications of the Berry.

553. The *Pome* (*pomum*, an apple) seen in the Apple, Pear, Quince,

Fig. 471.—Twisted or spiral legume of Medicago.

&c., is a fleshy fruit with the calyx adherent, and forming along with the epicarp and mesocarp a thick cellular mass, which is eatable, while the endocarp is scaly or horny, and forms separate cells enclosing the seeds. The covering of the cells is sometimes stony, as in the Medla (fig. 472), and the Holly, forming what has been called a *Nuculaniu* (*nucula*, a nut). In the Medlar, the stony endocarps are called *pyren* (πυρὴν, the stone of the fruit). In Cornus mas (fig. 473), there a two stony cells, *n*, surrounded by the fleshy epicarp and mesocarp, and as they are close together, and one is often abortive (fig. 473 2 *l*), there is a direct transition to the Drupe.



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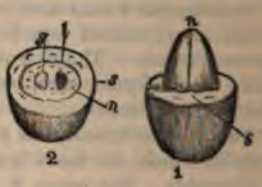

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554. **Dehiscent Syncarpous Fruits.**—The *Capsule* (*capsula*, a little chest). This name is applied generally to all dry syncarpous fruits, which open by valves or pores. The valvular capsule is observed in Digitalis (fig. 445), Hibiscus esculentus (fig. 449), Cedrela angustifolia (fig. 450), Mahogany (fig. 451), and Cerastium viscosum (fig. 444). The porous capsule is seen in the Poppy, Antirrhinum majus (fig. 462), and Campanula persicifolia (fig. 461). Sometimes the capsule opens by a lid, or by circumscissile dehiscence, and it is then called a *Pyxidium* (*pyxis*, a box), as in Anagallis arvensis (fig. 458), Henbane (fig. 459), and Lecythis. The capsule assumes a spiral form in the Helicteres, and a star-like or stellate form in Illicium anisatum. In certain instances, the cells of the capsule separate from each other, and open with elasticity to scatter the seeds. This kind of capsule is met with in Hura crepitans, and other Euphorbiaceæ, where the cocci, containing each a single seed, burst asunder with force (fig. 453); and in Geraniaceæ, where the cocci, each containing, when mature, usually one seed, separate from the carpophore, and become curved upwards

Fig. 472.—Fruit of common Medlar (*Mespilus germanica*). Transverse section showing *e*, epicarp. *s*, Sarcocarp. *n*, Endocarp, forming stony coverings of the seeds. The fruit has been called nuculanium, and the hard central cells pyrenæ. In the medlar, as well as in the apple, pear, and quince, the fruit may be considered as composed of stony or parchment-like follicles covered by a pulpy disk which lines the calyx.

Fig. 473.—Fruit of Cornus mas, common Cornel. 1. Transverse section detaching the upper half of the fleshy portion, *s*, so as to show the central kernel, *n*. 2. Transverse section of the fruit through the central portion, *n*, showing that it consisted of two loculaments. *l*, One of the loculaments empty, the other containing a seed, *g*.

y their adherent styles (fig. 455). In the former case, the fruit ollectively has been called *Regma* (ῥῆγμα, a rupture).

555. The *Siliqua* (*siliqua*, a husk or pod) (fig. 456), may be conidered as a variety of the capsule, opening by two valves; these are detached from below upwards, close to the sutures, bearing thin parietal placentas, which are united together by a prolongation called a *replum*, or spurious dissepiment, dividing the fruit into two. The seeds are attached on either side of the replum, either in one row or in two When the fruit is long and narrow, it is called *Siliqua;* when broad and short, it is called *Silicula.* It occurs in cruciferous plants, as Wallflower, Cabbages, Cresses, &c. The siliqua may be considered as formed of two carpels, and two parietal placentas united together so as to form a two-celled seed-vessel. Some say that in its normal state it consists of four carpels, and that two of these are abortive. There are four bundles of vessels in it, one corresponding to each valve, which may be called *valvular* or *pericarpial*, and others running along the edge called *placental.* The replum consists of two lamellæ. It sometimes exhibits perforations, becoming *fenestrate* (*fenestra*, a window). At other times its central portion is absorbed, so that the fruit becomes one-celled.

Fruits which are the produce of several Flowers united.

556. It sometimes happens that the ovaries of two flowers unite so as to form a double fruit. This may be seen in many species of Honeysuckle. But the fruits which are now to be considered, consist usually of the floral envelopes, as well as the ovaries of several flowers united into one, and are called *Multiple* or *Anthocarpous.*

557. The *Sorosis* (σωρὸς, a congeries or cluster) is a multiple fruit formed by a united spike of flowers, which becomes succulent. The fruit of the Pine-apple (fig. 474) is composed of numerous ovaries, floral envelopes, and bracts combined so as to form a succulent mass. The scales outside, *c c*, are the modified bracts and floral leaves, which, when the development of the fruit-bearing spike terminates, appear in the form of ordinary leaves, and constitute the crown, *f.* Other instances of a sorosis are the Bread-fruit and Jack-fruit. Sometimes a fruit of this kind resembles that formed by a single flower, and a superficial observer might have some difficulty in marking the difference. Thus, the Strawberry, Mulberry, and

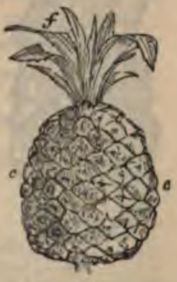

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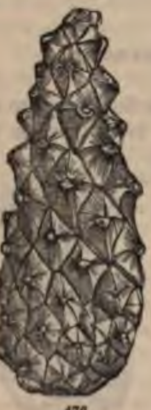
Fig. 474.—Anthocarpous fruit of Ananassa sativa, Pine-apple. Axis bearing numerous flowers, the ovaries of which are combined with the bracts, *c c*, to form the fruit. *f*, Crown of the Pine-apple, consisting of empty bracts or floral leaves.

Raspberry appear to be very like each other, but they differ tot their structure. The Strawberry and Raspberry are each the p of a single flower, the former being a succulent edible rec bearing achænia on its convex surface; the latter being a collec drupes placed on a conical unpalatable receptacle; the Mulberry (fig. 475) is a sorosis formed by nu flowers united together, the calyces becoming suc and investing the pericarps.

475

558. *Syconus* (σῦκον, a fig,) is an anthocarpous f which the axis, or the extremity of the pedun hollowed, so as to bear numerous flowers, all of whi united in one mass to form the fruit. The Fig (fig is of this nature, and what are called its seeds a achænia or monospermal seed-vessels of the numerous flowers sca through the pulpy hollowed axis. In Dorstenia (fig. 245), the less deeply hollowed, and of a harder texture, the fruit exh often very anomalous forms.

559. *Strobilus* (στρόβιλος, fir-cone) is a fruit-bearing spike m less elongated, covered with scales, each of which represents a se flower, and has two seeds base (fig. 476). The scales r considered as bracts, or as fla carpellary leaves, and the see naked, as there is no true present with its style or s This fruit is seen in the co Firs, Spruces, Larches, Cedar which have received the na Coniferæ, or cone-bearing, (account. The scales of the st are sometimes thick and united, so as to form a m less angular and rounded m in the Cypress (fig. 477); w the Juniper they become and are so incorporated as t a globular fruit like a ber 478), which has received the name of *Galbulus* (*galbulus*, nut cypress). In the Hop the fruit is called also a strobilus, but in scales are thin and membranous, and the seeds are not naked b contained in pericarps.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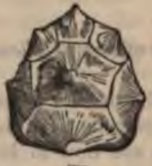
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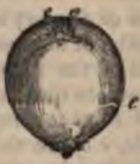

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Fig. 475.—Anthocarpous fruit of the Mulberry, formed by the union of several flower

Fig. 476.—Cone of Pinus sylvestris, Scotch Fir, consisting of numerous bracts or flo each of which covers two winged seeds. These seeds are called naked, in conseque being contained in an ovary, with a style or stigma.

Fig. 477.—Cone of Cupressus sempervirens, Cypress; one of the Gymnosperm *seeded plants*, like the Pine.

Fig. 478.—Succulent cone or Galbulus of Juniperus macrocarpa. *e e e e*, The differe *bracts united so as to enclose the seeds.*

560.—Tabular Arrangement of Fruits.

A. Simple Fruits formed from a single flower, and consisting of one or more Carpels either separate or combined; thus including Apocarpous, Aggregate, and Syncarpous Fruits.

I. Indehiscent Pericarps.

1. Usually containing a single seed:

Covered by a dry simple Pericarp.	Separable from the seed	Achænium (Lithospermum). *Mericarp* and *Cremocarp* in Umbelliferæ, and *Cypsela* in Compositæ.
	Achænia enclosed in fleshy tube of Calyx,	*Cynarrhodum* (Rose).
	Inseparable from the seed	Caryopsis (Grasses).
	Inflated	Utricle (Chenopodium).
	Having a cupulate involucrum	Glans (Acorn).
	Having winged appendages	Samara (Sycamore).
	Covered by a Pericarp, consisting of Epicarp, Sarcocarp, and Endocarp	Drupa (Cherry).
	Drupe, with a two-valved Endocarp, having divisions extending from its inner surface,	*Tryma* (Walnut).
	Aggregate Drupes,	*Etærio* (Raspberry).

2. Containing two or more seeds:

Immersed in a Fleshy or Pulpy mass.	Ovary adherent to Calyx, Placenta parietal, attachment of seeds lost when ripe	Bacca (Gooseberry).
	——— attachment permanent, rind thick and hard	Pepo (Gourd).
	Peculiar berried many-celled fruit, with two or more rows of Carpels	Balausta (Pomegranate).
	Ovary not adherent to Calyx, Placenta central	Uva (Grape).
	——— ——— Placenta parietal	Papaw fruit.
	Having a spongy separable rind, and separable pulpy cells	Hesperidium (Orange).
Enclosed in distinct Cells.	Walls of cells or Endocarp horny, covered by a fleshy Mesocarp and Epicarp or calycine disk,	Pomum (Apple).
	Walls of cells or Endocarp stony, covered by a fleshy Mesocarp and Epicarp or calycine disk,	Nuculanium (Medlar).

II. Dehiscent Pericarps.

Seeds in a dry Pericarp.	Opening by Ventral Suture only	Follicle (Pæony).
	Opening by Ventral and Dorsal Suture	Legume (Pea).
	Lomentum, a Legume separating into distinct pieces, each containing a seed (Ornithopus).	
	Opening by two valves which separate from a Central Replum or Frame	Siliqua (Cabbage). Silicula (Capsella).
	Opening by Transverse or Circumscissile Dehiscence	Pyxidium (Henbane).
	Opening by several valves or pores, without Ventral or Dorsal Suture or Replum	Capsule (Poppy).
	Capsule adherent to Calyx	Diplotegia (Campanula).
	A long pod-like Capsule	Ceratium (Glaucium).
	Opening by separation of elastic Cocci	Regma (Hura).

B. Fruits formed by the union of several Flowers, and consisting of Floral Envelopes as well as Ovaries; these are Multiple or Anthocarpous.

Hollow Anthocarpous Fruit.—Syconus (Fig).

Convex Anthocarpous Fruit.
- formed by Indurated Catkin.—Strobilus (Fir Cone).
- formed by Succulent Spike.—Sorosis (Bread-fruit.

7.—Maturation of the Pericarp.

561. After fertilization, the parts of the ovary begin to swell, the foramen of the ovule is more or less closed, the stigma becomes dry, and the style either withers and falls off, or remains attached as a hardened process or apiculum; while the embryo plant is developed in the ovule. It has been stated that fruits, such as Oranges and Grapes, are sometimes produced without seeds. It does not appear, therefore, necessary for the production of fruit in all cases, that the process of fertilization should be complete. In speaking of seedless Oranges, Dr. Bullar states that the thinness of the rind of a St. Michael Orange, and its freedom from pips, depend on the age of the tree. The young trees, when in full vigour, bear fruit with a thick pulpy rind and abundance of seeds; but as the vigour of the plant declines, the peel becomes thinner, and the seeds gradually diminish in number, till they disappear altogether.

562. While the fruit enlarges, the sap is drawn towards it, and a great exhaustion of the juices of the plant takes place. In Annuals this exhaustion is such as to destroy the plants; but if they are prevented from bearing fruit, they may be made to live for two or more years. Perennials, by acquiring increased vigour, are able better to bear the demand made upon them during fruiting. If large and highly-flavoured fruit is desired, it is of importance to allow an accumulation of sap to take place before the plant flowers. When a very young plant is permitted to bear fruit, it seldom brings it to perfection. When a plant produces fruit in very large quantities, gardeners are in the habit of thinning it early, in order that there may be an increased supply of sap to that which remains. In this way, Peaches, Nectarines, Apricots, &c., are rendered larger and better flavoured. When the fruiting is checked for one season, there is an accumulation of nutritive matter, which has a beneficial effect on the subsequent crop.

563. The pericarp is at first of a green colour, and performs the same functions as the other green parts of plants, decomposing carbonic acid under the agency of light, and liberating oxygen. Saussure found by experiments that all fruits in a green state perform this process of deoxidation. As the pericarp advances to maturity, it either becomes dry or succulent. In the former case, it changes into a brown or a white colour, and has a quantity of ligneous matter deposited in

ance, so as to acquire sometimes great hardness, when it is
le of performing any active process of vegetable life; in the
becomes fleshy in its texture, and assumes various bright
red, yellow, &c. In fleshy fruits, however, there is frequently
tion of ligneous cells in the endocarp, forming the stone of the
nd even in the substance of the pulpy matter or sarcocarp,
e found isolated cells of a similar nature, as in some varieties
where they cause a peculiar grittiness. The contents of the
ar the circumference of succulent fruits are thickened by
on, and a process of endosmose goes on, by which the thinner
of the inner cells pass outwards and thus cause swelling of
. As the fruit advances to maturity, however, this exhalation
es, the water becoming free, and entering into new combina-
In all pulpy fruits which are not green there are changes going
hich carbon is separated in combination with oxygen.

Dry fruits may remain attached to the tree for some time
hey are fully ripe, and ultimately separate by disarticulation.
ally, when the pericarp is thick, it separates in layers like
. Succulent fruits contain a large quantity of water, along
lulose or lignine, sugar, gummy matter or dextrine, albumen,
g matter, various organic acids, as citric, malic, and tartaric,
d with lime and alkaline substances, besides a pulpy gelatinous
which is converted by acids into pectine or pectose, whence
id is formed by the action of albumen. Pectine is soluble
r, and exists in the pulp of fruits, as Apples, Pears, Goose-
Currants, Raspberries, Strawberries, &c. Pectic acid is said
t of 2HO, $C^{32} H^{20} O^{28}$. It is changed into a jelly-like matter
a jelly); hence its use in making preserves. Each kind
is flavoured with a peculiar aromatic substance. Starch is
esent in the pericarp of the fruit, although it occurs commonly
seed. In Plantains, Bananas, and Bread-fruit, however,
y when seedless, there is a considerable quantity of starchy
iving rise to mealiness when these fruits are prepared as fritters.
tters are also found in the cellular tissue of many fruits. Thus,
il occurs in the Olive, and essential oils in the Orange, Lemon,
ue, Dictamnus, &c.

During ripening, much of the water disappears, while the
or lignine, and the dextrine, are converted into sugar. Berard
nion that the changes in fruits are caused by the action of the
of the air. Fremy found that fruits covered with varnish did
n. As the process of ripening becomes perfected the acids
with alkalies, and thus the acidity of the fruit diminishes,
s sweetness increases. The formation of sugar is by some
d to the action of organic acids on the vegetable constituents,
xtrine, and starch; others think that the cellulose and lignine

are similarly changed by the action of acids. The sugar of fruits is grape or starch sugar, called also Glucose. Its formula is $C^{12} H^{14} O^{14}$. In the Grape, when young, there is abundance of tartaric acid; but as the fruit advances to maturity, this combines with potash, so as to diminish the acidity. Certain fruits owe their aperient qualities to the saline matter which they contain. In seasons when there is little sun, and a great abundance of moisture, succulent fruits become watery, and lose their flavour. The same thing frequently takes place in young trees with abundance of sap, and in cases where a large supply of water has been given artificially.

566. The following analysis of the Cherry in its unripe and ripe state, as given by Berard, exhibits generally the chemical composition of succulent fruits:—

	Unripe.	Ripe.
Chlorophylle	0·05	—
Sugar	1·12	18·12
Gum or dextrine	6·01	8·23
Cellulose	2·44	1·12
Albumen	0·21	0·57
Malic Acid	1·75	2·01
Lime	0·14	0·10
Water	88·28	74·85
	100·00	100·00

The following table shows the changes produced on the water, sugar, and cellulose, in 100 parts of unripe and ripe fruits:—

	Water.		Sugar.		Cellulose.	
	Unripe.	Ripe.	Unripe.	Ripe.	Unripe.	Ripe.
Apricot	89·39	74·87	6·64	16·48	3·61	1·86
Peach	90·31	80·24	0·63	11·61	3·01	1·21
Cherries.	88·28	74·85	1·12	18·12	2·44	1·12
Plums	74·87	71·10	17·71	24·81	1·26	1·41
Pears	86·28	83·88	6·45	11·52	3·80	2·19

567. It is not easy in all cases to determine the exact time when the fruit is ripe. In dry fruits, the period immediately before dehiscence is considered as that of maturation; but, in pulpy fruits, there is much uncertainty. It is usual to say that edible fruits are ripe, when their ingredients are in such a state of combination as to give the most agreeable flavour. This occurs at different periods in different fruits. After succulent fruits are ripe in the ordinary sense, so as to be capable of being used for food, they undergo further changes, by the oxidation of their tissues, even after being separated from the plant. In some cases, these changes improve the quality of the fruit, as in the case of the Medlar, the austerity of which is thus still further diminished. In the Pear, this process, called by Lindley *bletting* (from the French, *blessi*), renders it soft, but still fit for food; while in the

Apple, it causes a decay which acts injuriously on its qualities. By this process of oxidation, the whole fruit is ultimately reduced to a putrefactive mass, which probably acts beneficially in promoting the germination of the seeds when the fruit drops on the gronnd.

568. The period of time required for ripening the fruit, varies in different plants. Most plants ripen their fruit within a year from the time of the expansion of the flower. Some come to maturity in a few days, others require some months. Certain plants, as some Coniferæ, require more than a year, and in the Metrosideros, the fruit remains attached to the branch for several years. The following is a general statement of the usual time required for the maturation of different kinds of fruit:—

Grasses	13 to 45	days.
Raspberry, Strawberry, Cherry	2	months.
Bird-cherry, Lime-tree	3	—
Roses, White-thorn, Horse-chestnut,	4	—
Vine, Pear, Apple, Walnut, Beech, Plum, Nut, Almond,	5 to 6	—
Olive, Savin	7	—
Colchicum, Mistleto	8 to 9	—
Many Coniferæ	10 to 12	—
Some Coniferæ, certain species of Oak, Metrosideros,	above 12	—

The ripening of fruits may be accelerated by the application of heat, by placing dark-coloured bricks below it, and by removing a ring of bark so as to lead to an accumulation of sap. It has been observed that plants subjected to a high temperature not unfrequently prove abortive, which seems to result from the over stimulation causing the production of unisexual flowers alone. Trees are sometimes made to produce fruit, by checking their roots when too luxuriant, and by preventing the excessive development of branches.

569. **Grafting.**—A very important benefit is produced, both as regards the period of fruiting and the quality of the fruit, by the process of grafting. This is accomplished by taking a young twig or scion, called a *graft*, and causing it to unite to a vigorous stem or *stock*, thus enabling it to derive a larger supply of nutritive matter than it could otherwise obtain, and checking its vegetative powers. In place of a slip or cutting, a bud is sometimes taken. In order that grafting may be successfully performed, there must be an affinity between the graft and the stock as regards their sap, &c. It has often been supposed that any kinds of plants may be grafted together, and instances are mentioned by Virgil and Pliny, where different fruits are said to have been borne on the same stock. This was probably produced by what the French call *Greffe des charlatans*,—cutting down a tree within a short distance of the ground, and then hollowing out the stump, and planting within it several young trees of different species; in a few years they grow up together so as to fill up the cavity, and appear to

be one. The deception is kept up better, if some buds of the paren stock have been kept alive. Fortune gives an instance in the Punjaub of a Peach growing out of an old Mango tree about six or eigh feet from the ground. In this case the Peach had its roots in th ground, and had grown through the hollow stem of the Mango.

570. The object which gardeners wish to secure by grafting, is th improvement of the kinds of fruit, the perpetuation of good varieties, which could not be procured from seed, and the hastening of the period of the fruit-bearing. Grafting a young twig on an older stock has the effect of making it flower earlier than it would otherwise do. The accumulation of sap in the old stock is made beneficial to the twig, and a check is given at the same time to its tendency to produce leaves. Although the general law is, that grafting can only take place between plants, especially trees, of the same family, there are certain exceptions. Loranthaceous parasites can form a union with genera in different orders.

571. Mr. Knight did much to improve fruits by grafting. He believed, however, that a graft would not live longer than the natural limit of life allowed to the tree from which it has been taken. In this way he endeavoured to account for the supposed extinction of some valuable varieties of fruits, such as the Golden pippin, and many cider apples of the seventeenth century.* He conceived that the only natural method of propagating plants was by seed. His views have not been confirmed by physiologists. Many plants are undoubtedly propagated naturally by shoots, buds, tubers, &c., as well as by seed; and it is certain that the life of slips may be prolonged by various means, much beyond the usual limit of the life of the parent stock. The Sugar-cane is propagated naturally by the stem, the Strawberry by runners, the Couch-grass by creeping stems, Potatoes and Jerusalem Artichokes by tubers, the Tiger-lily by bulblets, and Achimenes by scaly bodies, like tubers. The fruits, moreover, which Mr. Knight thought had disappeared, such as Red streak, Golden pippin, and Golden Harvey, still exist, and any feebleness that they exhibit does not appear to proceed from old age, but seems to be owing to other causes, such as the nature of the soil, cold, violence, and mutilation. Vines have been transmitted by perpetual division from the time of the Romans. A slip taken from a Willow in Mr. Knight's garden, pronounced by him as dying from old age, was planted in the Edinburgh Botanic Garden many years ago, and is now a vigorous tree, although the original stock has long since undergone decay. It is true, however, that a cutting taken from a specimen already exhausted by excessive development of its parts, will partake of the impaired vigour of its parent, and will possess less constitutional energy than that taken from a vigorous stock.

572. In grafting, various methods have been adopted. One of these

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* See Knight's Horticultural Papers, 8vo, London, 1841, p. 81.

grafting by approach, or *inarching*, when two growing plants are ited together, and after adhesion one is severed from its own stock, d left to grow on the other. This kind of adhesion sometimes takes ace naturally in trees growing close together. It is well seen in a -tree in the burying-ground at Killin. The branch of the same tree y also be bent, so as to become united to the stem at two points. is is often seen in the Ivy. The roots of contiguous trees occasion-y unite by a process of grafting, and to this is attributed the con-ued vigour of the stump of Spruce-trees cut down on the Swiss untains. This natural grafting of roots has been observed in the hite Pine (*Abies pectinata*), and sometimes in the Red Pine (*Abies elsa*), as well as in the Scotch Fir (*Pinus sylvestris*).

573. The usual method of grafting is by *scions* or *slips*, which are plied to the stock by a sloping surface, or are inserted into slits it by *cleft-grafting*, or into perforations by *wimble* or *peg-grafting*. *hip-grafting* or *tongue-grafting* is performed by inserting a tongue cleft process of the stock between the lips of a cut in the scion. *le-grafting* resembles whip-grafting, but is performed on the side the stock without heading it down. Sometimes several slips are ced in a circular manner round the inside of the bark of the stock *crown-grafting;* or the bark of a portion of the stock is removed, l that of the scion is hollowed out, so as to be applied over it like parts of a flute, hence called *flute-grafting*. *Budding* is practised the removal of a bud from one plant, along with the portion of bark and new wood, and applying it to another plant, in which a ilar wound has been made. Grafting is usually performed between woody parts of the plants, but herbaceous parts may also be ted in this way. The graft and stock are secured by clay, or by s'-wax and tallow, or by Indian rubber, gutta percha, or collodion.

74. By grafting, all our good varieties of apples have been pro-ed from the Crab Apple. The seeds of the cultivated apples, when n, produce plants which have a tendency to revert to the original r Crab. Grafted varieties can only be propagated by cuttings. influence exercised by the stock is very marked, and it is of great ortance to select good stocks on which to graft slips. In this way fruit is often much improved by a process of *ennobling*, as it is ed. The scion also seems in some cases to exercise a remarkable ct on the stock. Slips taken from varieties with variegated leaves, fted on non-variegated, have caused the leaves of the latter to me variegation, and the effect, when once established, has con-ed even after the slip was removed. The effects of grafting are l seen in the case of the Red Laburnum, when united to the Yellow cies. The Red Laburnum is a hybrid between the common Yellow urnum and Cytisus purpureus, or the Purple Laburnum. The nches below the graft produce the ordinary yellow laburnum

flowers of large size; those above exhibit often the small purple laburnum flowers, as well as reddish flowers intermediate between the two in size and colour. Occasionally, the same cluster has some flowers yellow and some purplish.

8.—Seed or Fertilized Ovule arrived at Maturity.

575. While the pistil undergoes changes consequent on the discharge of the pollen on the stigma, and ultimately becomes the fruit, the ovule also is transformed, and, when fully developed, constitutes the *seed*. After fertilization, the foramen of the ovule contracts, the embryo or young plant gradually increases in its interior, by the absorption of the fluid matter contained in the sac of the amnios, solid nutritive matter is deposited, and a greater or less degree of hardness is acquired. The seed then is the fecundated mature ovule containing the embryo, with certain nutritive and protective appendages. When ripe, the seed contains usually a quantity of starchy and ligneous matter, azotised compounds, as caseine and vegetable albumen, oily and saline matters. It sometimes acquires a stony hardness, as in the case of vegetable ivory, the seed of Phytelephas macrocarpa. Care must be taken not to confound it with single-seeded pericarps, such as the Achænium and Caryopsis, in which a style and stigma are present; nor with bulbils or bulblets, as in Lilium bulbiferum, and Dentaria bulbifera, which are germs or separable buds developed without fecundation.

576. Seeds are usually enclosed in a seed-vessel or pericarp, and hence the great mass of flowering plants are called *angiospermous* (ἄγγος, or ἀγγεῖον, a vessel, and σπέρμα, a seed). In Coniferæ and Cycadaceæ, however, the seeds have no true pericarpial covering, and fertilization takes place by the direct application of the pollen to the seed, without the intervention of stigma or style. Hence the seeds, although sometimes protected by scales, are truly naked, and the plants are called *gymnospermous* (γυμνὸς, naked, and σπέρμα, a seed). Occasionally, by the early rupture of the pericarp, seeds originally covered become exposed. This is seen in Leontice, Cuphea, &c. In Mignonette, the seed-vessel (fig. 479), opens early, so as to expose the seeds, which are called *seminude*.

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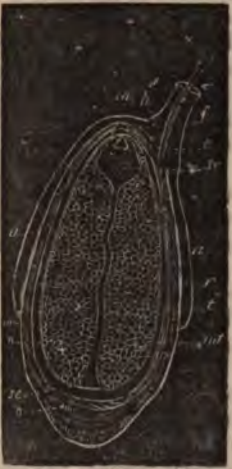
577. Besides being contained in a pericarp, the seed has its own peculiar coverings. Like the ovule, it consists of a *nucleus* or *kernel*, and *integuments*. In some instances, although rarely, all the parts of the ovule are visible in the seed, viz., the embryo-sac, or quintine, the quartine, the tercine or covering of the nucleus, the secundine, and

ig. 479.—Fruit or capsule of Reseda opening early, so that the ovules become seminude.

ne. In fig. 480, there is a representation of the seed of alba, in which *s e* indicates the ic, containing the embryo, *e*; *n*, ır farinaceous covering (quartine), und the embryo-sac; *m t*, mem med round the nucleus (tercine) cundine; *t*, the primine. In gene- ver, great changes take place by the ent of the embryo; the embryo-sac bsorbed, or becomes incorporated ellular tissue of the nucleus; the g occasionally takes place in the , so that in the ripe seed, all that etected is the embryo and two The general covering of the led *spermoderm* (σπέρμα, seed, and ering). In order to correspond name applied to the covering of it ought more properly to be ted *perisperm* (περί, around, and ed). This latter term, however, appropriated to a certain portion d, to be afterwards noticed under the name of *albumen*.



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he Spermoderm usually consists of two parts, an *external* , called the *episperm* or *testa* (ἐπί, upon, or on the outside, α, a seed, or *testa*, a shell), and an *internal membrane*, called a (ἔνδον, within, and πλευρά, side). The former may consist of the primine and secundine, or of the primine only, when nally happens, the secundine is absorbed; the latter, of a on between the membrane of the nucleus and the embryo- one of these parts alone. Sometimes the secundine remains the seed, forming what has been called a *mesosperm* (μέσος, and when it assumes a fleshy character, it has received the *arcosperm* or *sarcoderm* (σάρξ, flesh).

he Episperm consists of cellular tissue, which often assumes lours, and becomes more or less hardened by depositions in r. In Abrus precatorius, and Adenanthera pavonina, it is t red colour; in French beans, it is beautifully mottled; in nd, it is veined; in the Tulip and Primrose, it is rough; in lragon, it is marked with depressions; in Cotton and Ascle-

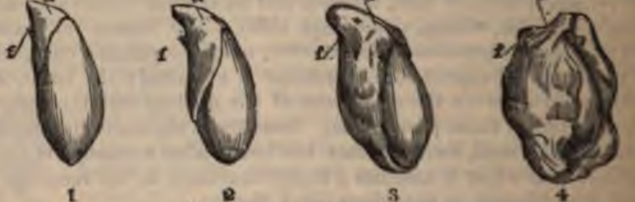
Young seed of Nymphæa alba cut vertically. *f*, Funiculus or umbilical cord. *a*, ed from the placenta. *r*, Raphe. *c*, Chalaza or cotyledonary end of the seed. *h*, e of the seed. *m*, Micropyle or foramen. *t*, Testa or Primine. *m t*, Secundine. r membrane of the nucleus. *n*, Farinaceous external perisperm or albumen formed s, and probably constituting the quartine of Mirbel. *s e*, *s e*, Internal perisperm or rmed by the embryo-sac. *e*, The embryo.

pias, it has hairs attached to it; and in Mahogany and Bignonia, it is expanded in the form of wing-like appendages. In Salvia, Collomia, Acanthodium, and other seeds, it contains spiral cells, from which, when moistened with water, the fibres uncoil in a beautiful manner, having a membranous covering. In the episperm of the seed of Ulmus campestris, the cells are compressed, and their sinuous boundaries are traced out by minute rectangular crystals adhering to their walls.

580. **The Endopleura** is also cellular. It is often thin and transparent, but it sometimes becomes thickened. It is applied more or less closely to the embryo, and sometimes follows a sinuous course, forming folds on its internal surface, and separating from the episperm.

When the embryo-sac remains distinct from the nucleus in the seeds, as in Nymphæa, Zingiber, Piper, &c., it forms a covering to which the name of *vitellus* (*vitellus*, yolk of an egg), was given by Gærtner.

581. **Arillus.**—Sometimes there is an additional covering to the seed, derived from an expansion of the funiculus or placenta after fertilization, to which the name *arillus* has been given. This is seen in the Passion-flower, where the covering commences at the base, and proceeds towards the apex, leaving the foramen uncovered. In the Nutmeg and Spindle-tree, this additional coat is said to commence at the side of the exostome, and to proceed from above downwards, constituting, in the former case, the substance called *mace;* and in the latter, the bright scarlet covering of the seeds (figs. 481, 482). In such instances, it has been called by some an *arillode*. This arillode, after growing downwards, may be reflected upwards, so as to cover the foramen.



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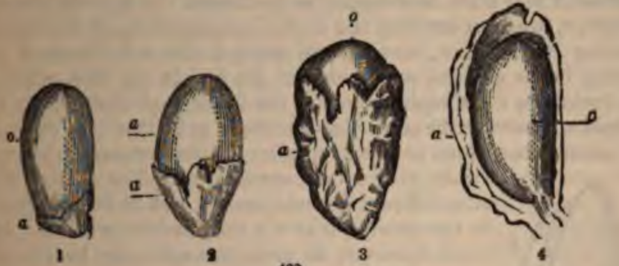
582. On the testa, at various points, there are produced at times cellular bodies, which are not dependent on fertilization, to which the name of *strophioles* (*strophiolum*, a little garland), or *caruncules* (*carun-*

Fig. 481.—1, 2, 3, and 4, Various states of the arillus of Euonymus, the Spindle-tree. The figures show the mode in which it is developed from the edges of the foramen. *a a a a*, Arillode. *f f f f*, Foramen or exostome.

cula, a little piece of flesh), has been given, the seeds being strophiolate or carunculate. These tumours may occur near the base or apex



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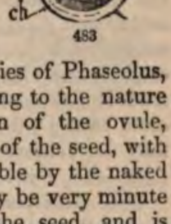
of the seed, they may be swellings of the exostome, as in Ricinus (fig. 483 *c*), or they may occur in the course of the raphe.



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583. Seeds are attached to the placenta by means of a funiculus or umbilical cord, which varies much in length. In Magnolias it attains a great length, and when the seed is ripe it appears like a cord suspending it from the follicle. The point of the seed by which it is united to the cord or the scar left on its separation, is called the *hilum* or *umbilicus*, and represents its base. It frequently exhibits marked colours, being black in the Bean, white in many species of Phaseolus, &c. It may occupy a small or large surface, according to the nature of the attachment. What constitutes the foramen of the ovule, becomes the *micropyle* (μικρὸς, small, and πύλη, gate) of the seed, with its exostome and endostome. This may be recognizable by the naked eye, as in the Pea and Bean tribe, Iris, &c., or it may be very minute and microscopic. It indicates the true apex of the seed, and is important as marking the part to which the root of the embryo is directed. At the micropyle in the Bean, is observed a small process of integument, which, when the young plant sprouts, is pushed up like a lid, and is called *embryotega* (*tego*, I cover.) The fibro-vascular bundles, from the placenta pass through the funiculus and reach the seed, either entering it directly at a point called the *omphalode* (ὀμφαλὸς, navel,) which forms part of the hilum, or being prolonged between the

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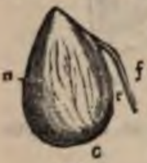
Fig. 482.—Development of the same arillus, *a*, around the ovule, *o*, exhibited in a different position. 1, 2, 3, 4, are four successive stages of development. In fig. 4, the arillus has been cut vertically, to show its relation to the ovule, which it surrounds completely.

Fig. 483.—Vertical section of a carpel of Ricinus communis, and of the seed which it contains. *c*, Pericarp. *l*, Loculament. *f*, Funiculus or umbilical cord. *t*, Integuments of the seed, having at their apex a caruncula, *c*, which is traversed by the small canal of the exostome. The exostome does not correspond exactly with the endostome, which is immediately above the radicle. *r*, Raphe. *c h*, Chalaza. *p*, Perisperm or albumen, the upper portion of which only is seen. *e*, Embryo, with its radicle, *e r*, and its cotyledons, *e c*.

outer and inner integument in the form of a *raphe*, and reaching the *chalaza* or organic base of the nucleus, where a swelling or peculiar expansion may often be detected, as in Crocus. In fig. 480, the spiral vessels, *r*, are seen entering the cord, *f*, passing through the hilum, *h*, forming the raphe, *r*, between the testa, *t*, and endopleura, *m i*, and ending in the chalazal expansion, *c*. So also in fig. 484, where *f* is the funiculus, *r* the raphe united to the hilum and chalaza, *c*, whence vessels, *n*, penetrate the seed. In some seeds, as Narthecium ossifragum, the vessels are said not to appear till after fertilization, and in Habenaria viridis, none have been detected. The chalaza is often of a different colour from the rest of the integuments. In the Orange, it is of a reddish-brown colour. Sometimes, however, its structure can only be recognized by careful dissection. It indicates the cotyledonary extremity of the embryo. The hilum and chalaza may correspond, or they may be separated from each other and united by the raphe (fig. 484). The raphe is generally on the side of the seed next the ventral suture.



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584. The positions of the hilum, micropyle, and chalaza, are of importance in determining the nature of the seed. The hilum is the base of the seed, and the micropyle its apex, while the chalaza is the organic base of the nucleus. The hilum and chalaza may correspond, the micropyle being at the opposite extremity, and then the seed is *orthotropal* (ορθὸς, straight). The seed may be curved so that the micropyle is close to the hilum, and the chalaza, by the growth of the seed on one side, may be slightly removed from the hilum, then the seed is *campylotropal* (καμπύλος, curved). The micropyle may be close to the hilum, and the chalaza in the progress of development may be removed to the opposite end, then the seed is *anatropal* (ἀνατρέπω, I reverse).*

585. The position of the seed as regards the pericarp, resembles that of the ovule in the ovary, and the same terms are applied—erect, ascending, pendulous, suspended, curved, &c. (figs. 423, 424, 425, 426, 420.) These terms have no reference to the mode in which the fruit is attached to the axis. Thus the seed may be erect while the fruit itself is pendent, in the ordinary meaning of that term. The part of the seed next the axis or the ventral suture is its *face*, the opposite side being the *back*. Seeds exhibit great varieties of forms. They may be flattened laterally, *compressed*; or from above downwards, *depressed*. They may be round, oval, triangular, polygonal, rolled up like a snail, as in Physostemon; or coiled up like a snake, as in Ophiocaryon paradoxum.

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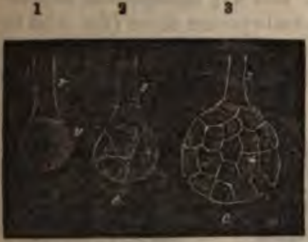
* See ¶ 467, where these terms are more fully explained when treating of the ovule.

Fig. 484.—Seed of the Hazel. *f*, Funiculus. *r*, Raphe. *c*, Chalaza. *n*, Veins spreading in a radiating manner over the integuments of the seed.

586. The great object of fertilization is the formation of the embryo in the interior of the seed. In general, one embryo is produced, constituting what is denominated *monembryony* (μόνος, one); but in Coniferæ, Cycadaceæ, Mistleto, &c., there are frequently several embryos, giving rise to what is called *polyembryony* (πολὺς, many). Sometimes two embryos become united together in the same seed. In the coniferous seeds, numerous corpuscles are seen whence the embryos proceed. The process of fertilization has already been traced until the embryo appears as a rounded cellular body, enclosed in the embryo-sac, and attached to a suspensor. In fig. 480, *e* is the embryo, and *s e* the embryo-sac. In this sac there is at first a mucilaginous fluid, the *amnios*, in which cells are speedily developed, commencing on its inner surface, and extending towards the interior. The embryonic-cell (fig. 485 *v*), still attached to the sac by its suspensor, *s*, contains in the early state semifluid granular matter, which becomes organized, producing distinct nucleated cells (fig. 485, 2, *e*). These gradually multiply, and form at length a cellular mass, at first undivided (fig. 485, 3, *e*), but afterwards showing a separation of parts, so that the axis and lateral projections or rudiments of leaves can be distinguished. In figs. 486 to 491, all the stages of the formation of embryo can be traced; appearing first as a simple cell (figs. 486, 488), forming others in its interior (figs. 489, 490); and finally, the parts of the embryo becoming visible, as in fig. 491, where *g r* is the axis representing the



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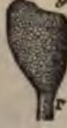

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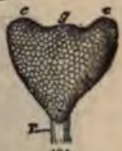


491

Fig. 485.—First development of the embryo of Draba verna. *o*, Suspensor, which in this plant is very long. *v*, Embryonic or germinal vesicle. *e*, Embryo. 1. First stage, in which the embryonic vesicle only is seen. 2, Second stage, showing several cells formed in the embryonic vesicle. 3. Third stage, in which the embryo becomes more conspicuous in consequence of the formation of numerous small cells.

Fig. 486.—Monocotyledonous embryo of Potamogeton perfoliatus in its early stage, appearing as a vesicle or simple cell.

Fig. 487.—The same further advanced, showing radicle, *r*, gemmule or plumule, *g*, and the cotyledon, *c*.

Fig. 488.—Dicotyledonous embryo of Œnothera crassipes in its early stage, appearing as a vesicle or cell.

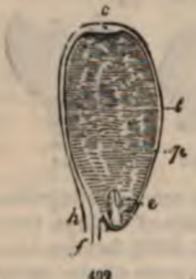
Fig. 489. The same further advanced, showing three united utricles or cells.

Fig. 490.—The same more developed, showing numerous cells.

Fig. 491.—The same in a more developed state, showing radicle, *r*, gemmule, *g*, and cotyledons, *c c*.

stem and roots, and *c c* are the lateral projections, which are devel
as leaf-like bodies, called *cotyledons* (κοτυληδὼν, the name of a
having leaves like seed-lobes.)

587. **Perisperm or Albumen.**—As the embryo increases in si
gradually causes absorption of the cellular tissue in the embryo-sac
it is sometimes developed to such a degree as to reduce the nucleu
embryo-sac to a thin integument. In such a case the seed consi
integuments and embryo alone. In Santalum, Osyris, and Loran
Griffith says the ovule is sometimes reduced entirely to a sort of emb
nary sac. In Avicennia, the embryo, at its maturity, is on the ou
of the nucleus and body of the ovule. In other cases it enlarges
certain extent, filling the embryo-sac completely or partially, and
encroaching slightly on the cells of the nucleus. The cells surroun
the embryo then become filled with a deposit of solid matter c
albumen, consisting of starchy, oily matter, and nitrogenous compou
To this matter some have applied the term *perisperm* (περὶ, aro
and σπέρμα, seed); others, that of *endosperm* (ἔνδον, within). The n
perispermic albumen, or *perisperm*, is often restricted to that foun
the cells of the nucleus alone (fig. 480 *n*); *endospermic albume*
endosperm, to that found within the embryo-sac alone (fig. 480 *s*
in Chelidonium majus, Ranunculaceæ, Umbelliferæ, &c. Someti
both kinds of albumen occur in the same seed, as in Nymphæ



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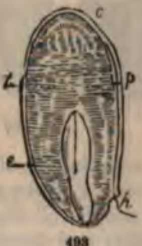

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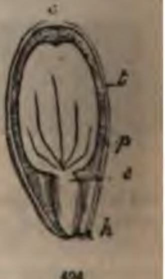


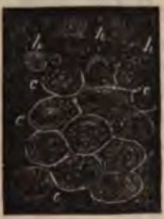
494

and Piperaceæ. Schleiden states, that in some instances the albu
is produced in the region of the chalaza. He also remarks, that e
spermic albumen is common in Endogens. In some Scrophularias
embryo-sac forms little cavities or bags, which in the ripe seed re
as appendages to the albumen. Seeds in which the embryo occu

Fig. 492.—Anatropal matu e seed of Helleborus niger cut vertically. The embryo, *e*, is
as compared with the perisperm or albumen, *p*. *t*, Spermoderm or coverings of the se
Funiculus. *h*, Hilum. *c*, Chalaza.

Fig. 493.—Mature seed of Diphylleia peltata, showing an embryo, *e*, which occupies a
portion of the seed than in fig. 494. Letters indicate the same parts as in the previous fig
Fig. 494.—Ripe seed of Berberis vulgaris, exhibiting a larger embryo, *e*, as compared wi
perisperm, *p*. Letters as in figs. 492 and 493.

, are called *exalbuminous* (*ex*, without), as Compositæ,
nost Leguminosæ, while others having separate albumen
. The larger the quantity of albumen in a seed, the
)ryo. In figs. 492 to 494, the relative proportion which
ars to the albumen or perisperm in different seeds is
; the embryo with its cotyledons and young root, *p* the
e coverings of the seed, *f* the funiculus or cord, *h* the
he chalaza. In fig. 492, the embryo is minute, and
small part of the apex of the albumen; in fig. 493, it
as encroached on the perisperm; while in fig. 494, it
veloped, much of the albumen having been absorbed.
bumen varies much in its nature and consistence, and
tant characters. It may be *farinaceous* or *mealy*, con-
f cells filled with starch (fig. 495), as in Cereal grains,
ndant; *fleshy* or *cartilaginous*, consisting of thicker cells
soft, as in the Coco-nut, and which sometimes contain
ily albumen of Croton (fig. 496), Ricinus, and Poppy;
e matter in the cells is of a hard consistence, and often
oncentric manner, so as nearly to fill the entire cavity,
ry-Palm, and Coffee. The albumen may be uniform
it may present a mottled appearance, as in the Nutmeg,
nonaceæ, and some Palms (fig. 497), where it is called



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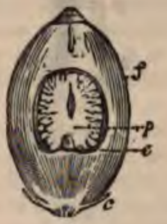

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nis mottled appearance depends on the endopleura or
ent forming folds on which the albumen is deposited,
seed is ripe, these foldings of the membrane divide the
inuous or convoluted manner.
bumen is a store of matter laid up for the nourishment
In the Coco-nut and double Coco-nut, it forms the
the seed, weighing many ounces, while the embryo is

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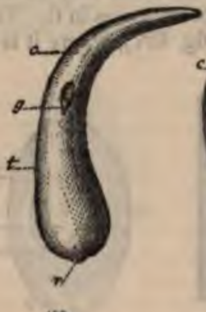
of a small portion of the farinaceous perisperm or albumen of Zea Mais,
Cells. *fff*, Grains of starch in the cells.
of a small portion of the oily perisperm or albumen of Croton Tiglium.
Drops of oil contained in the cells.
l section of the fruit of Areca Catechu. *c*, Perianth. *f*, Pericarp. *p*, Rumi-
lbumen. *e*, Embryo.

minute, weighing a few grains, and lies in a cavity at one extremity. In Coffee, the albumen is the horny portion, the infusion of which is used for a beverage. In Phytelephas it is called vegetable ivory from its hardness, and is used for the same purposes as ivory. In the horny albumen of this Palm, as well as in that of the Attalea funifera, the Date and the Doom Palm, the concentric deposition of secondary layers, leaving a small cavity in the centre of the cells, and radiating spaces uncovered with thickening matter, is well seen under the microscope.

498

590. The embryo consists of *cotyledons* or rudimentary leaves, the *plumule* (*plumula*, a little feather), or *gemmule* (*gemma*, a bud), representing the ascending axis, the *radicle* (*radix*, root), or the descending axis, and their point of union the *collum*, collar or neck; that part of the axis which intervenes between the collar and cotyledons being the *caulicule* (*cauliculus*, a little stalk), or *tigelle* (*tigellus*, a little stalk). The embryo varies in its structure in the different divisions of the vegetable kingdom. In acrogenous and thallogenous plants, it continues as a cell or spore, with granular matter in its interior (fig. 498), without any separation of parts or the production of cotyledons. Hence these plants are called *acotyledonous* (α privative κοτυληδών). Endogenous and Exogenous plants, on the other hand, exhibit a marked separation of parts in their embryo, the former having one cotyledon, and hence being *monocotyledonous* (μόνος, one); the latter two, and hence *dicotyledonous* (δὶς, twice). Thus, the whole vegetable kingdom is divided into three



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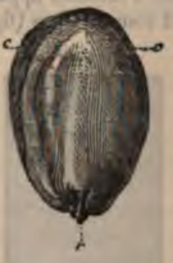

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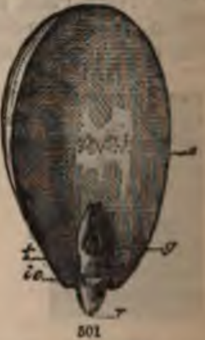

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Fig. 498.—Acotyledonous embryo of Marchantia polymorpha. Such embryos bear the name of spores.

Fig 499.—Monocotyledonous embryo of Potamogeton perfoliatus nearly mature. *r*, Radicle. *t*, Caulicule or tigellus. *c*, Cotyledon. *g*, Gemmule or plumule.

Fig. 500.—Mature dicotyledonous embryo of the common Almond. *r*, Radicle or young root.

Fig. 501.—The same, with one of the cotyledons removed. *r*, Radicle. *t*, Tigelle or caulicule. *c*, One of the cotyledons left. *i c*, Cicatrix left at the place where the other cotyledon was attached. *g*, Gemmule composed of several small leaves.

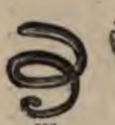
lasses by the nature of the embryo, the first of which classes nds with the cryptogamic division of plants, the second with ogenous division of phanerogamous or flowering plants, the th the exongenous division of the same. Fig. 499 represents otyledonous embryo, with its cotyledon, *c*; while figs. 500 and hibit a dicotyledonous embryo, with its cotyledons, *c c*.

The Spore of acotyledonous plants (fig. 498) is a cellular om which a new plant is produced. Germination takes place art of its surface, and not from fixed points. Some consider oduced independent of any process of fertilization, others con- e union of two kinds of cells as necessary for its formation. ormed, it sometimes presents filaments or vibratile cilia on its (figs. 431-434), by means of which it moves about in fluids, e of the Infusoria. When it germinates, these cilia disappear. es spores are united in definite numbers, as in fours, sur- by a cellular covering, or *perispore* (περὶ, around, and σπορὰ, , or *sporidium*, and thus forming the reproductive body called ore (τετρὰς, four), which is common in Algæ.

Embryo.—In the *embryo* or *corculum* (*corculum*, a little heart), part formed is the *axis*, having one of its extremities turned the suspensor, and the other in the opposite direction; the indicating the point whence the young root or *radicle* is to and the latter that whence the leafy *stem* is to arise. As the es produced are the cotyledons, this stem is called the *cotyle-* extremity of the embryo, while the other is the *radicular*. icular is thus continuous with the suspensor, and consequently owards the micropyle (fig. 494 *h*), or the summit of the an important fact in practical botany; while the cotyledonary, pposite, is pointed towards the base of the nucleus or the (fig. 494 *c*). Hence, by ascertaining the position of the le and chalaza, the two extremities of the embryo can in be discovered. In some rare instances, in consequence of a ng taking place in the coats of the seed, as in Ricinus (fig. 483), e Euphorbiaceæ, there is an alteration in the micropyle, so radicle does not point directly to it.

The part of the axis which unites the radicle and the cotyledon edons, is denominated *caulicule* or *tigelle* (figs. 499 *t*, 501 *t*). sometimes very short. From the point where the cotyledons ed to the axis, a bud is developed (in the same way as from of leaves); this bud contains the rudiments of the true or ial (*primus*, first, and *ordo*, rank) leaves of the plant, and has led *plumule* or *gemmule*. This bud may be seen usually lying he cotyledons. Thus, in fig. 501, the embryo of the Almond the gemmule, *g*, lying on one of the cotyledons, the other been removed and leaving a cicatrix, *i c*; while in fig. 499, the gemmule, *g*, of Potamogeton perfoliatus, is covered by the single cotyledon, *c*.

594. The gemmule as well as the cotyledon are sometimes obscurely seen. Thus, in Cuscuta (fig. 502), the embryo appears as an elongated axis without divisions; and in Pekea butyrosa (fig. 503), the mass of the embryo is made up by the radicular extremity and tigelle, *t*, in a groove of which, *s*, the cotyledonary extremity lies embedded, which when separated, as in the figure, shows only very small cotyledons. In some monocotyledonous embryos, as Orchidaceæ, it requires a microscopic examination to detect the cotyledonary leaf.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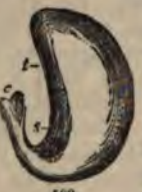

503

595. **Monocotyledonous Embryo.**—In this embryo, the single cotyledon in general encloses the gemmule at its lower portion, and exhibits on one side a small slit (fig. 504 *f*), which indicates the edges of the vaginal, or sheathing portion of the cotyledonary leaf. The embryo presents commonly a cylindrical form, rounded at the extremities, or a more or less elongated ovoid (fig. 504). At first sight there seems to be no distinction of parts; but on careful examination, by moistening the embryo, and making a vertical section, there will be detected, at a variable height, a small projecting mammilla, buried a little below the surface. This is the gemmule which marks the termination of the axis. From the lower extremity proceeds the radicular portion (figs. 499 *t r*, 504 *r*), which may be said to represent both the tigelle and radicle. The upper portion or chalazal end of the embryo, is the cotyledon (figs. 499, 504 *c*), which is sheathing at its base, so as to enclose the gemmule. The length of the radicular portion, or that below the gemmule, varies. It is usually shorter than the cotyledon, and is denser in structure; but in some instances it becomes much larger, giving rise to what has been called a *macropodous* embryo (μακρὸς, long, and ποῦς, a foot). Thus, in fig. 505, *t* represents the long radicular portion in the young state, whence ultimately the root, *r*, proceeds. Occasionally, the radicular portion becomes very thick and large, so as to form a considerable portion of the embryo; and in all monocotyledons, it may be considered as an enlarged mammillary projection, whence the rootlets proceed by bursting through it, and carrying with them a covering or sheath (¶ 127, fig. 124).

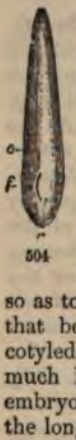

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Fig. 502.—Spiral embryo of Cuscuta or Dodder.

Fig. 503.—Embryo of Pekea butyrosa. *t*, Thick tigelle or caulicule, forming nearly the whole mass, becoming narrowed and curved at its extremity, and applied to the groove, *s*. In the figure this narrowed portion is slightly separated from the groove. *c*, Two rudimentary cotyledons.

Fig. 504.—Embryo of Triglochin Barrelieri. *r*, Radicle. *f*, Slit corresponding to the gemmule. *c*, Cotyledon.

596. When considering endogenous or monocotyledonous stems, it was shown that the leaves are produced singly and alternately, in a sheathing manner, each embracing the subsequently developed bud. So it is in the monocotyledonous embryo. There is a single leaf or cotyledon produced, and if in any instance there is more than one, it is alternate with the first formed. The cotyledon (fig. 504 *c*) is folded either partially, as in Dioscorea, or completely. Its sheathing portion (vagina) embraces the bud or gemmule, which appears as a mammillary projection; its position being indicated by a cleft or slit (fig. 504 *f*), where the edges of the sheath unite. All the portion of the embryo above the gemmule, is the cotyledon; all below, the radicle.

597. **Dicotyledonous Embryo.**—The form of this embryo varies much; and although sometimes resembling in its general aspect that of monocotyledons, yet it is always distinguished by a division taking place at the cotyledonary extremity, by which it is separated into two, more or less evident, lobes. The parts of this embryo are easily traced in the Bean, Pea, Acorn, and Almond. In the latter (fig. 500), the embryo has an oval form, consisting of two thick cotyledons, *c c*, and a radicle, *r*. When one of the cotyledons is removed (fig. 501), leaving scars, *i c*, the gemmule or plumule, *g*, is seen included between them, with its caulicule or tigelle, *t*.

598. The cotyledons are not always, however, of the same size. Thus, in a species of Hiræa (fig. 506), one of them, *c′*, is smaller than the other; and in Carapa guianensis (fig. 507), there appears to be only one, in consequence of the intimate union which takes place between the two as indicated by the dotted line, *c*. The union between the cotyledonary leaves may continue after the young plant begins to germinate. Such embryos have been called

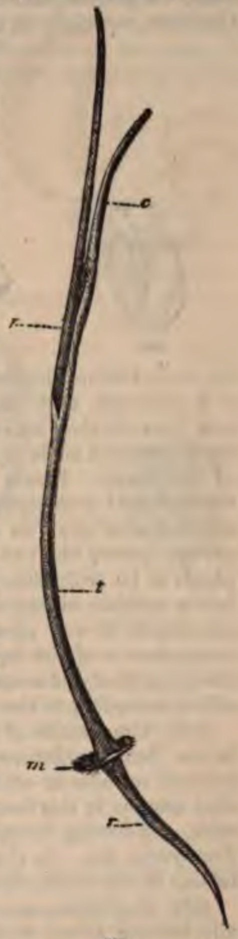

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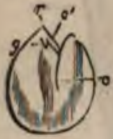
Fig. 505.—Monocotyledonous embryo of Zannichellia palustris germinating. *m*, Collum or neck, the point intermediate between the stem or tigelle, *t*, and the radicle or root, *r*. *c*, Cotyledon. *g*, Gemmule or plumule.

pseudo-monocotyledonous (ψευδής, false). When there are two cotyl dons, they are opposite to each other. In some cases there are mo than two present, and then they become verticillate. This occurs Coniferæ, especially in the Fir (fig. 508), Spruce, and Larch, in whi



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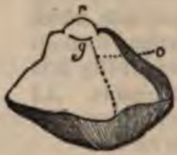

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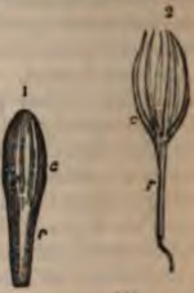

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six, nine, twelve, and even fifteen have been observed. In such cas it is probable that the cotyledons are split by collateral choris and thus divided into several. They are linear, and resemble their form and mode of development the clustered or fasciculated lea of the Larch. Plants having numerous cotyledons are occasiona denominated *polycotyledonous*. Duchartre thinks that the multi cotyledons of the Firs are not verticillate, but occur in two oppo groups, placed like two ordinary cotyledons. Hence he considers t plants to be truly dicotyledonous, with the cotyledons deeply divid into a number of segments. Between the two cotyledons there is slit which is well seen in Pinus Pinaster and excelsa. Thus, t arrangement of the cotyledons follows the same law as that of t leaves in dicotyledonous or exogenous plants, being opposite or ver cillate according to the mode of formation of the axis.

599. The texture of the cotyledons varies. They may be thick, in the Bean, exhibiting only slight traces of venation, with their f internal surfaces in contact, and their backs more or less convex; they may be in the form of thin and delicate laminæ, flattened on b sides, and having distinct venation, as in Ricinus (fig. 509), Jatrop Euonymus, &c. In the former case they are called *fleshy*, or semi lobes; in the latter, *foliaceous*, or seminal leaves.

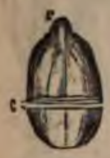
600. Cotyledons are usually entire and sessile. But they occasio ally become lobed, as in the Walnut and the Lime (fig. 510), wh

Fig. 506.—Embryo of Hiræa Salzmanniana, cut vertically, to show the inequality of the cotyledons, one of which, *c*, forms almost the whole mass of the embryo. *c'*, The small cotyle *g*, Gemmule or plumule. *r*, Radicle.

Fig. 507.—Embryo of Carapa guianensis, cut vertically, to show the union of the cotyle the distinction between which is only indicated by a faint line, *c*. *r*, Radicle. *g*, Gemmule.

Fig. 508.—Embryo of Fir. 1. Taken from the seed. 2. Beginning to germinate. *r*, Rad *c*, Cotyledons, which are numerous; the plant being polycotyledonous.

the cotyledon, *c*, has five lobes; or petiolate, as in Geranium molle (fig. 511 *p*); or auriculate, as in the Ash (fig. 512 *o*). Like leaves in the bud (see Vernation, ¶ 184), cotyledons may be either applied directly to each other (fig. 509), or may be folded in various ways. In the Almond (fig. 500) they lie in the direction of the axis. In other cases they are folded laterally, *conduplicate* (fig. 513); or from apex to base, *reclinate* (fig. 205 *a*); or rolled up laterally, so as partially to embrace each other, *convolute* (fig. 514); or rolled up like the young fronds of ferns, *circinate* (fig. 515.) In these cases, both cotyledons follow the same direction in their foldings or convolutions; but, in other instances, they are folded in opposite directions, resembling the equitant (fig. 205 *m*) and semi-equitant (fig. 205 *n*) vernation.



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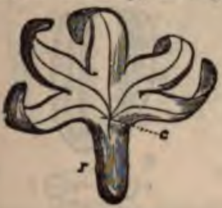

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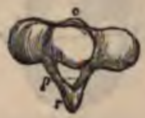

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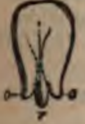

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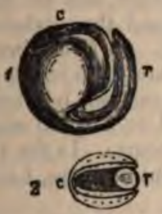

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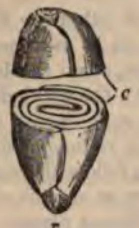

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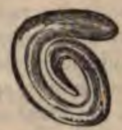

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601. The radicle may be either straight or curved, and, in particular instances, it gives a marked character to the seed. Thus, the divisions of the order Cruciferæ are founded on the relative position and folding of the radicle and cotyledons. In the division *Pleurorhizeæ*

Fig. 509.—Embryo of Ricinus communis taken out of the seed (see fig. 483), and cut transversely. The two halves are separated so as to show the two cotyledons, *c*, applied to each other. *r*, Radicle.

Fig. 510.—Embryo of the Lime. *r*, Radicle. *c*, One of the divided or palmate cotyledons.

Fig. 511.—Embryo of Geranium molle. *r*, Radicle. *c*, Cotyledons attached to the collar by a stalk or petiole, *p*.

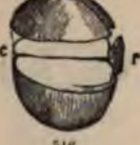
Fig 512.—Embryo of the Ash. *r*, Radicle. *c*, One of the cotyledons. *o o*, Auricular appendages to the cotyledon.

Fig. 513.—Embryo of Brassica oleracea, Cabbage. *r*, Radicle. *c*, Cotyledon. 1. Entire embryo. 2. Embryo cut transversely, showing the cotyledons folded on the radicle or conduplicate The radicle is dorsal, or on the back of the cotyledons.

Fig. 514.—Embryo of Punica Granatum, Pomegranate, cut into two halves. The upper half removed to show the convolute cotyledons. *r*, Radicle.

Fig. 515.—Circinate embryo of Bunias orientalis.

(πλευρὰ, side, and ῥίζα, root), the cotyledons are applied by the faces, and the radicle (figs. 516, 517 *r*) is folded on their edges, so to be *lateral*, while the cotyledons, *c*, are *accumbent* (*accumbo*, I lie the side). In *Notorhizeæ* (νῶτον, back), the cotyledons (fig. 518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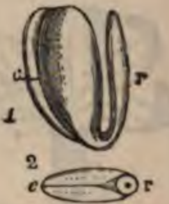

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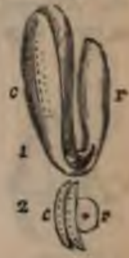

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are applied to each other by their faces, and the radicle, *r*, is folded on their back, so as to be *dorsal*, and the cotyledons are *incumben* (*incumbo*, I lie upon, or on the back). In *Orthoploceæ* (ὀρθὸς, straight, and πλόκος, a plait), the cotyledons are *conduplicate* (fig 513, 1, 2, *c*), while the radicle, *r*, is dorsal, and enclosed between their folds. In other divisions, the radicle is folded in a spiral manner (fig. 515), and the cotyledons follow the same course. In the Dodder (fig. 502), the embryo appears as an axis without divisions, having several turn of the spiral on different planes.

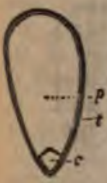
602. The seed sometimes is composed of the embryo and integu ments alone, the former being either straight or folded in vario ways, as already shown. In other cases there is an addition of p sperm or nutritive matter, in greater or less quantity, according the state of development which the embryo attains (figs. 492, 494). When the embryo is surrounded by the perisperm on all except its radicular extremity (fig. 494,) it becomes *internal* or *intr* (*intra*, within); when lying outside the perisperm, and only co into contact with it at certain points, it is *external* or *extrarius* (without). When the embryo follows the direction of the axis seed, it is *axile* or *axial*, and it may be either *external*, so as to into contact with the perisperm only by its cotyledonary ap 519), or *internal* (figs. 492, 493, 494). In the latter case, the lar extremity may, as in some Coniferæ, become incorporat the perisperm apparently by means of a thickened suspensor. the embryo is not in the direction of the axis, it becomes *ab*

Fig. 516.—Embryo of a Pea, cut transversely. Upper half separated to show th cumbent cotyledons, *c*. *r*, Radicle applied laterally.

Fig 517.—Embryo of Isatis tinctoria. *c*, Accumbent cotyledons. *r*, Radicle. entire. 2. Transverse section of the embryo.

Fig. 518.—Embryo of Cheiranthus Cheiri, Wallflower. *c*, Incumbent cotyledons. 1. Embryo entire. 2. Transverse section of the embryo.

abaxial (fig. 520 *e*); and in this case it may be either straight or curved (fig. 521), internal or external. In the straight seed of Grasses, the perisperm is abundant, and the embryo lies at a point on its surface, immediately below the integuments, being straight and external. In Campylotropous ovules, the embryo is curved, and in place of being embedded in perisperm, is frequently external to it, following the concavity of the seed (fig. 522), and becoming *peripherical* (περιφέρω, I carry round), with the chalaza situated in the curvature of the embryo.



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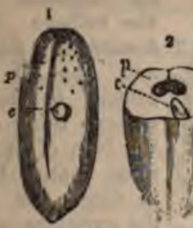

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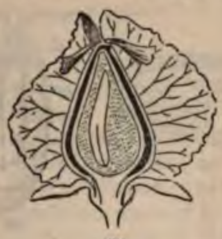

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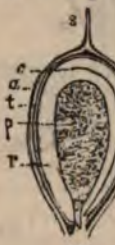

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603. It has been already stated, that the radicle of the embryo is directed to the micropyle, and the cotyledons to the chalaza. In some cases, by the growth of the integuments, the former is turned round so as not to correspond with the apex of the nucleus, and then the embryo has the radicle directed to one side, and is called *excentric*, as is seen in Primulaceæ, Plantaginaceæ, and many Palms, especially the Date (fig. 520). The position of the embryo in different kinds of seeds varies. In all cases the radicle or base of the embryo points more or less directly to the micropyle, while the cotyledonary extremity is directed towards the chalaza. In an orthotropal seed, then, the embryo is inverted or *antitropal* (ἀντὶ, opposite, τρέπω, I turn), the radicle pointing to the apex of the seed, or to the part opposite the hilum (fig. 521). Thus, fig. 523 represents an orthotropal seed of Sterculia Balanghas, attached to the pericarp, *p c*, by the funiculus, *f*. The chalaza and hilum are confounded together at *c h*, the micropyle being at the opposite end. The integuments of the seed, *t*, cover the embryo with its perisperm, *p s*; the cotyledons, *c*, point to the hilum and chalaza; while the radicle, *r*, points to the

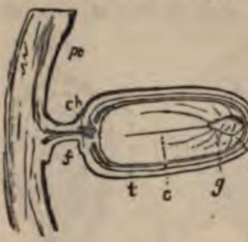
Fig. 519.—Grain of Carex depauperata, cut vertically. *t*, Integuments. *p*, Perisperm. *c*, Embryo.

Fig. 520.—Seed or kernel of the Date. *p*, Perisperm or horny albumen. *e*, Embryo. 1. Entire seed. 2. Seed cut transversely at the point where the embryo, *e*, is situated.

Fig. 521.—Winged fruit of Rumex, cut vertically, to show the abaxile or abaxial slightly curved embryo.

Fig. 522.—Carpel of Mirabilis Jalapa, cut vertically, with the seed which it contains. *a*, Pericarp crowned with the remains of the style, *s*. *t*, Integuments of the seed or spermoderm. *e*, Peripherical embryo with its radicle, *r*, and its cotyledons, *c*. *p*, Perisperm or albumen surrounded by the embryo.

micropyle, and the embryo is thus reversed or inverted. Again, in an anatropal seed (figs. 493, 494), where the micropyle is close to the hilum, and the chalaza at the opposite extremity, the embryo is *erect* or *homotropal* (ὅμοιος, like, and τρέπω, I turn), the radicle or base of the embryo being directed to the base of the seed. In some anatropal ovules, as in Castor oil (fig. 483), the exostome is thickened or caruncuIate, *c*, and the endostome does not correspond exactly to it, so that the radicle, *e r*, of the embryo is directed to a point a little removed from the exostome. In curved or campylotropal seeds, (fig. 419), the embryo is folded so that its radicular and cotyledonary extremities are approximated, and it becomes *amphitropal* (ἀμφὶ, around, and τρέπω, I turn). In this instance the seed may be exalbuminous, and the embryo may be folded on itself (fig. 524), or albuminous, the embryo surrounding more or less completely the perisperm, and being peripherical (fig. 522). In fig. 524, the seed of Erysimum cheiranthoides is shown, with the chalaza, *c h*, and the hilum, *h*, nearly confounded together, the micropyle, *m*, the embryo occupying the entire seed, with the radicle, *r*, folded on the cotyledons, *c*, which enclose the plumule, *g*. Thus, by determining the position of the hilum, chalaza, and micropyle, the direction of the embryo may be known.



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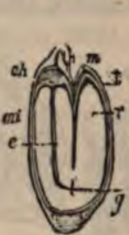

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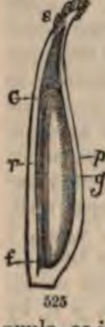

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604. According to the mode in which the seed is attached to the pericarp, the radicle may be directed upwards or downwards, or laterally, as regards the ovary. In an orthotropal ovule, attached to the base of the pericarp, it is superior (fig. 521.) So also in a suspended anatropal ovule, as in fig. 483. In other anatropal ovules, as in figs. 492, 504, 525, the radicle is inferior. When the ovule is horizontal as regards the pericarp (fig. 523), the radicle, *r*, is either centrifugal, when it

Fig. 523.—Orthotropal seed of Sterculia Balanghas, cut longitudinally, with the portion of the pericarp, *p c*, to which it is attached. *f*, Funiculus. *c h*, Chalaza and hilum confounded together. *t*, Integuments of the seed, or spermoderm. *p s*, Perisperm, the summit of which only is seen. *c*, One of the cotyledons. The other cotyledon has been removed to show the gemmule, *g*. *r*, Radicle which is directed to the foramen at the apex of the seed. The embryo is antitropal or inverted.

Fig. 524.—Campylotropal seed of Erysimum cheiranthoides, cut longitudinally. *m*, Micropyle. *c h*, Chalaza not far removed from the hilum, *h*. *t*, Testa or episperm. *en t*, Inner covering of the seed or endopleura. *r*, Radicle. *c*, Cotyledons. *g*, Gemmule. The embryo is curved or amphitropal.

Fig. 525.—Vertical section of the carpel of Triglochin Barrelieri. *p*, Pericarp crowned by the sessile stigma, *s*. *g*, Seed. *f*, Funiculus. *r*, Raphe. *c*, Chalaza

points to the outer wall of the ovary; or centripetal, when it points
o the axis or inner wall of the ovary.

9.—Functions of the Seed.

605. The seed contains the embryo or germ, which, when placed
favourable circumstances, is developed as a new plant. The em-
ryo is usually of a whitish or pale colour, resembling the perisperm
hen present, and sometimes scarcely distinguishable from it at first
ght. Occasionally, however, it is of a greenish or yellow hue.
stances of this occur in the *perispermic* or albuminous seed of Euony-
us, and the *aperispermic* or exalbuminous seeds of most Cruciferæ.
he changes which take place in the composition of the seed, and in
s coats, are with the view of protecting the embryo from vicissitudes
temperature, moisture, &c., and of laying up a store of nourish-
ent for its after growth. The coats become thickened and hardened
y the deposition of lignine; and in its interior, starch, nitrogenous
mpounds, phosphates, and sulphates, besides oily and fatty matters,
rious organic acids, tannin, and resins, are found. The specific
avity of the seed is much increased, so that it usually sinks in water,
d it becomes more capable of resisting decomposition, and preserv-
g the vitality of the embryo. In some instances where air is con-
ined in their envelopes seeds float in water.

606. When seeds are matured, they are detached from the plant in
rious ways. They separate from the funiculus at the hilum, and
main free in the cavity of the pericarp, which either falls along with
em, or opens in various ways so as to scatter them. The elasticity
ith which some seed-vessels open during the process of desiccation
very great. It may be seen in Hura crepitans, Common Broom,
d Cardamine. In the Geranium (fig. 455), the seed-vessels are
iled upwards on the elongated beak, and in this way the seeds are
opped. In the Cyclamen the peduncle curves towards the earth so
to place the seed-vessels in a position suitable for germination. In
e succulent fruit of Momordica Elaterium, or squirting Cucumber,
e cells vary in their size and contents in different parts; some con-
ning thick matter become distended at the expense of others with
inner contents, and the force of endosmose ultimately causes rup-
re of the valves at their weakest point, viz., where they are united
the peduncle. When this takes place, the elasticity of the valves
ds out the seeds and fluid contents with great force through the
ening left by the separation of the peduncle. In the Impatiens or
lsam, the seed-vessel opens with force by a similar process, the five
lves curving inwards in a spiral manner, in consequence of the dis-
nsion of the outer large cells. The seeds are discharged before they
e dry. In the case of Mignonette (fig. 479), the seed-vessel opens

early, so as to expose the seeds; and in Cuphea, the placenta pierces the ovary and floral coverings early, so as to render the seeds naked. Fleshy fruits, which fall from the tree when ripe, supply by their succulent portion the most suitable nutriment for the young embryo in its earliest stages of growth.

607. Wind, water, animals, and man, are instrumental in the dissemination of seeds. Some seeds, as those of Mahogany, Bignonia, Tecoma, Pine, Asclepias, Epilobium, and the Cotton plant, have winged or feathery appendages, by means of which they are wafted to a distance. The same thing occurs in some indehiscent seed-vessels, as the samara of the Sycamore and Ash, and the achænia of Dandelion, Thistles, &c. Moisture, as well as dryness, operates in the bursting of seed-vessels. The pod of the Anastatica, or Rose of Jericho, and the capsule of some Mesembryanthemums, exhibit the effects of moisture in a remarkable degree. Animals, by feeding on fleshy fruits, the kernels of which resist the action of the juice of the stomach, disseminate seeds; and man has been the means of transporting seeds from one country to another. In some cases, the pericarps ripen their seeds under ground, and are called *hypocarpogean* (ὑπό, under, καρπός, fruit, and γέα, earth). This is seen in the Arachis hypogæa, or Ground nut. Others, as Vicia amphicarpos, have both aerial and subterranean fruit. Many seeds are used for food by animals, and a great destruction of them takes place from decay: but this is compensated for by the vast number produced, so as to secure the continuance of the species. The quantity of seeds produced by many plants is very great. In single capsules of Poppy and Tobacco, upwards of 40,000 have been counted.

608. **Germination.**—The act by which the embryo of a seed leaves its state of torpidity, and becomes developed as a new plant, is called *germination* (*germinatio*, springing). In order that this process may go on, a certain combination of circumstances is necessary. The chief requisites are moisture, air, and a certain temperature. Exclusion from light is also beneficial. In Cotyledonous plants germination may be defined as the act by which the fecundated embryo of a seed leaves the state of torpor in which it has remained for a longer or shorter period, starts into life, as it were, comes out from its envelope, and sustains its existence until such time as the nutritive organs are developed

609. *Moisture* is necessary in order that the nutritive matters may be taken up in a state of solution, and that certain changes may take place in the seed. Dry seeds will not germinate. Until water be absorbed no circulation of fluids in the seed can take place. The quantity of water absorbed by seeds is often very large. Decandolle found that a French bean, weighing 544 millegrammes, absorbed 756 of water. The swelling of Peas by absorption of water is familiar to

all. The kernels or seeds by this means are enabled to burst their stony coverings.

610. *The temperature* required for germination varies in different seeds Some demand a tropical heat, others are satisfied with the warmth of our spring. In general, the requisite temperature may be said to vary from 60° to 80° F. Some seeds can bear a temperature which would kill others. Some have been known to germinate after exposure for a short time to the heat of boiling syrup, others after exposure to a cold of —39° F. Many plants grow in the immediate vicinity of very hot springs, others in cold regions. Edwards and Colin, from their experiments, were led to fix 95° F. as the highest limit of prolonged temperature which cereal grains can bear in water; and 113° F as the highest they can bear in sand or earth. Vegetable life has been observed progressing under much higher temperatures. In the Manilla Islands, a hot spring which raised the thermometer to 187° had plants flourishing in it and on its borders. A species of Chara grows in the hot springs of Iceland, and various Confervæ in the boiling springs of Arabia and of the Cape of Good Hope. Wheat, Oats, and Barley, are said to thrive in any country where the mean temperature exceeds 65° F. The spores of certain cryptogamic plants are especially fitted for cold countries. Edwards and Colin found that seeds in a dry air bore a higher temperature than in water or steam.

611. *Air*, or rather *oxygen*, was shown by Scheele to be necessary for germination. Seeds deeply buried in the soil, and excluded from air, do not spring. The depth at which seeds should be sown, varies from half an inch to two inches, according to the nature of the soil. The following experiments were made by Petri:—

Seed sown to the depth of	Came above ground in	No. of plants that came up.
½ inch	11 days	7-8ths.
1 —	12 —	all.
2 —	18 —	7-8ths.
3 —	20 —	6-8ths.
4 —	21 —	4-8ths.
5 —	22 —	3-8ths.
6 —	23 —	1-8th.

Shallow sowing is thus proved to be the best.

612. Seeds, when buried deep in the soil sometimes lie dormant for a long time, and only germinate when the air is admitted by the process of subsoil ploughing, or other agricultural operations. When ground is turned up for the first time, it is common to see a crop of white clover and other plants spring up, which had not been previously seen in the locality. After the great fire in London, plants sprung up, the seeds of which must have long lain dormant; and the same thing is observed after the burning of forests, and the draining

of marshes. Gardner says that the name *capoeira* is given in Brazil to the trees which spring up after the burning of the virgin forests (*matos virgens* and *capoes*), and that they are always very distinct from those which constituted the original vegetation. Mr. Vernon Harcourt mentions a case where turnip seeds lay in a dormant state for seven or eight years, in consequence of being carried down to a great depth in the soil. On the Calton Hill, at Edinburgh, when new soil was turned up some years ago for building, a large crop of Fumaria micrantha sprung up; and seeds gathered from under six feet of peat-moss in Stirlingshire have been known to germinate. Mr. Kemp mentions the germination of seeds found at the bottom of a sand-pit 25 feet deep, which he concludes, from various circumstances, to have been deposited more than 2000 years ago. The seeds were farinaceous, belonging to the natural order Polygonaceæ. A weak solution of chlorine is said to accelerate germination, probably by the decomposition of water, and the liberation of oxygen.

613. *Darkness* is favourable to germination. Seeds germinate best when excluded from light. M. Boitard showed this by experiments on Auricula seeds, some of which were covered by a transparent bell-jar, others by a jar of ground glass, and a third set by a jar enveloped in black cloth. The last germinated most rapidly. Senebier concluded that the height and size of a plant were proportionate to the intensity of the illumination, its verdure dependent on the quality of the rays. Mr. Hunt says that the luminous or light-giving rays, and those nearest the yellow, have a marked effect in impeding germination; the red or heat-giving rays are favourable to the process, if abundance of water is present; while the blue rays, or those concerned in chemical action or *actinism*, accelerate the process and caûse rapid growth. His experiments were performed by making the sun's rays pass through different kinds of coloured glass. He believes that the scorching effect of the sun on leaves may be prevented by the use of blue glass, and that a high temperature might be obtained by red glass. He has suggested a pale-green glass made with oxide of copper, as that best fitted for conservatories. By this means he expects that the scorching rays of light will be excluded, while no hindrance is given to the passage of the others; the green colour being a compound of yellow or luminous, and of blue or chemical rays. A delicate emerald-green glass has been employed lately at his suggestion, in glazing the large Palm-house at Kew.

614. Some have said that *electricity* prevents germination, but facts are wanting to confirm this. The experiments of Dr Fyfe,[*] Mechi, Coventry, and others, have shown that the statements made in regard to the efficacy of electro-culture are erroneous.

615. In order that plants may germinate vigorously, moisture,

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[*] See Trans. of Soc. of Arts, vol. iii. part ii. p. 109.

at and air must be supplied in due proportion. If any of them are eficient, or in excess, injury may be done. It is of great importance, erefore, in agricultural operations, that the ground should be well ulverized, the seeds regularly sown at a proper and equal depth, and he soil drained. Pulverized soil, when examined, is found to consist f small particles having cavities in their interior, and separated from ach other by interstitial spaces. In a very dry soil, all these cavities re full of air, in a very wet undrained soil, they are full of moisture; hile in a perfectly drained soil, the interstices are full of air, while he particles themselves are moist. The seed in such a soil is under he influence of heat, air, and moisture, and is excluded from light. Hence it is in very favourable circumstances for germination. Frost has an important effect in pulverizing the soil, by the expansion of the water contained in the particles, when it is converted into ice. Snow again, acts in giving a covering to the young plant, protecting it from intense frost and sudden alternations of temperature, and by its slow melting allows the plant to accommodate itself to the mild atmosphere. Snow contains often much oxygen.

616. If a field is not equally planted, the seeds will sink to different depths, and will spring up very irregularly. The seeds should be placed at a depth not greater than two inches. *Draining* acts not merely in removing superfluous moisture, but in allowing a constant renewal of nutritive matter, more especially of ammonia and carbonic acid from the atmosphere, in giving a supply of air, and in keeping up a proper temperature in the soil. In an undrained soil the water s stagnant, and there is little supply of fresh nutriment, and much old is produced. Of late there has been a discussion as to whether hallow or deep draining is the best. Much depends on the nature of he soil, and it is impossible to lay down any fixed rule applicable to ll cases. Mr. Smith says that drains in very stiff soils should be ifteen feet apart, and in very light soils thirty or forty; the depth eing from thirty to thirty-six inches, and the main drains six inches leeper than the parallel ones. In extremely stiff clays, he makes rains two and a-half feet deep. He was the first to advocate the ystem of parallel drains, or what is called *thorough-draining*.

617. **Vitality of Seeds.**—Some seeds lose their vitality soon, others etain it for a long time. Coffee seeds, in order to grow, require to be own immediately after ripening. On the other hand, Melon seeds have een known to retain their vitality for upwards of forty years, and hose of the Sensitive plant for more than sixty years. Oily seeds in general lose their vitality quickly, probably from their power of absorbing oxygen, and the chemical changes thus induced. Considerable iscussions have taken place as to the length of time during which eeds will retain their germinating powers. Lindley mentions a case n which young plants were raised from seeds found in an ancient

barrow in Devonshire, along with some coins of the Emperor Hadrian; and M. des Moulins relates an instance of seeds capable of germinating, which were discovered in a Roman tomb, supposed to be fifteen or sixteen centuries old. In these instances, it is to be remarked, that the seeds were protected from the influences required for growth, and were preserved in circumstances which cannot be easily imitated. There seems to be great doubts as to the seeds found in the catacombs of Egypt, and in mummy cases, having actually produced living plants. The statements relative to Mummy Wheat have not been confirmed, and there are many sources of fallacy.

618. With the view of preserving seeds, it is of importance that they should be thoroughly ripened, kept in a uniform temperature, and in a dry state, and not directly exposed to the oxygen of the air. They are often best kept in their seed-vessels. The hard coverings of many foreign legumes, and of the cones of Firs, &c., seem to be of importance in preserving the germinating power of seeds. Seeds not fully ripened are very apt to decay, and are easily affected by moisture. Seeds, although fit for food, may have lost their germinating power. Corn, pulse, and farinaceous seeds generally will live for a long time if gathered ripe, and preserved quite dry. In sending seeds from foreign countries, they should be put into dry papers, and exposed to free ventilation in a cool place; as, for instance, in a coarse bag suspended in a cabin. Oily seeds and those containing much tannin, as beech-mast, acorns, and nuts, must not only be ripe and dry, but also must be excluded from the air. When transported, they are often put into dry earth and sand, and pressed hard, or preserved in charcoal powder, the whole being covered with tin, and put into a stout box. Some have suggested their preservation in hermetically-sealed bottles full of carbonic acid gas. Seeds enveloped in wax sent from India germinated well. They had been kept for three months, and were quite firm and fresh. They did not sprout for a month, but afterwards grew strong and healthy. Seeds sent in cotton and brown paper had grown considerably in their transit, and, when potted, grew fast, but soon displayed symptoms of debility. Spanish chestnuts and filberts have been sent enveloped in wax to the Himalayahs, and are now growing there. Cuttings of fruit trees, with their ends enveloped in wax, were also sent, and arrived in a living state. In this way also, apples, pears, and plums have been sent.

619. M. Alphonse Decandolle made experiments on the vitality of seeds. He took 368 species of seed, fifteen years old, collected in the same garden, and sowed them at the same time, and in the same circumstances as nearly as possible. Of the 368, only seventeen germinated, and comparatively few of the species came up. The following are the results:—

					Per cent.
Malvaceæ	5	came up out of	10	species	0·50
Leguminosæ	9	— —	45	—	0·20
Labiatæ	1	— —	30	—	0·03
Scrophulariaceæ	0	— —	10	—	0·00
Umbelliferæ	0	— —	10	—	0·00
Caryophyllaceæ	0	— —	16	—	0·00
Gramineæ	0	— —	32	—	0·00
Cruciferæ	0	— —	34	—	0·00
Compositæ	0	— —	45	—	0·00

In 357 species, of which the duration of life was known, the results were:—

					Per cent.
Annuals	9	came up out of	180	species	5·0
Biennials	0	— —	28	—	0·0
Perennials	4	— —	105	—	3·8
Ligneous	3	— —	44		6·7
	16		357		4·4

or it may be thus given—

					Per cent.
Monocarpic	9	came up out of	208	species	4·3
Polycarpic*	7	— —	149	—	4·7
	16		357		4·4

620. Woody species thus seem to preserve the power of germinating longer than others, while biennials are at the opposite end of the scale; perennials would appear to lose their vitality sooner than annuals. Large seeds were found to retain the germinating power longer than small ones, and the presence or absence of separate albumen or perisperm did not seem to make any difference. Compositæ and Umbelliferæ lost their germinating power very early. From these experiments, Decandolle concludes that the duration of vitality is frequently in an inverse proportion to the rapidity of the germination. This subject has been investigated by a committee of the British Association, under the direction of Professor Daubeny.

621. **Chemical changes during Germination.**—During the process of germination, certain changes take place in the contents of the seed, by which they are rendered fit for the nourishment of the embryo. In exalbuminous or aperispermic seeds, where the embryo alone occupies the interior, these changes are effected principally in the matters stored up in the cotyledons. In albuminous or perispermic seeds, on the other hand, the changes occur in the substance of the perisperm. One of the most remarkable of these changes is the conversion of starch into dextrine and grape sugar by a process of oxidation, the object being the conversion of an insoluble into a soluble substance. A nitrogenous compound, called Diastase (¶ 310), is developed during

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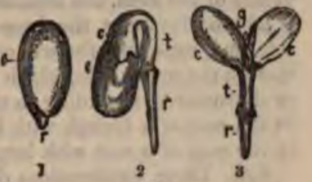
* For an explanation of these terms, see ¶ 634.

germination, and is said to act on the starch. This diastase may be probably a portion of gluten passing into a state of decomposition, and acting as a ferment. The change of starch into dextrine and sugar is referred by chemists to catalytic action, or the action of contact, and to the influence exercised by diastase and other matters in making a new arrangement of the molecules. While this conversion of starch into sugar proceeds, oxygen is absorbed, carbonic acid is given off, and heat is produced. It is probable that at this period there is a certain amount of electric disturbance. Carpenter states that the conversion of the starch of the seed into sugar involves the liberation of carbonic acid, with a small quantity of acetic acid; and as all acids are negative, and like electricities repel each other, it is probable that the seed is at the time in an electro-negative condition. The phenomena of germination are well seen in the malting of barley, which consists in the sprouting of the embryo and the formation of sugar. The changes produced in the air by germinating seeds have been investigated by Saussure, who showed that in all cases carbonic acid was evolved at the expense of the carbon of the seed.

622. When all the requisites for germination are supplied, the seed, by the absorption of moisture, becomes softened and swollen. When albumen or the perisperm is present, it undergoes certain chemical changes by the action of the air and water, so as to be rendered fit for the nutrition of the embryo. These changes consist partly in the conversion of starch into sugar, and are accompanied with the evolution of carbonic acid, and the production of heat. As the fluid matters are absorbed by the cells of the embryo, the latter continues to increase until it fills the cavity of the seed, and ultimately bursts through the softened integuments. In cases where there is no perisperm, the exalbuminous embryo occupies the entire seed, and the process of germination goes on with greater rapidity. The embryo speedily swells, ruptures the integument, and is nourished at the expense of the cotyledons, which are often fleshy, containing much starchy matter, as in the Bean and Pea, along with oily matter, as in the Nut and Rape seed. There are thus two stages of germination—that in which the embryo undergoes certain changes within the seed itself, and that in which it protrudes through the integuments and becomes an independent plant.

623. The embryo, then, nourished at the expense of its perisperm and cotyledons, continues to grow, and usually protrudes its radicular extremity (fig. 526, 1) in the first instance, which is nearest the surface, and next the micropyle. This, which in the embryo is very short, and confounded with the cauliculus so as to form the first internode, becomes thickened by addition to its extremity (fig. 526, 2), and the division between the ascending and descending axis becomes more marked. The caulicule or axis also elongates, bearing at its

nmit the plumule, which now appears outside the integuments (fig. 6, 3, *g*), forming the second internode, either accompanied by the tyledons, or leaving them still within e seed coats. In the latter case, the tyledons are usually fleshy and of a le colour, and become gradually sorbed like the perisperm. In the rmer they assume a more or less leafy pect, exercising the functions of leaves r a certain period, and ultimately ecaying. While the radicle descends wards the centre of the earth, producing roots of a pale colour, the umule has a tendency to ascend, forming the leafy axis, and assuming green colour under the influence of light and air.



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624. **Direction of Plumule and Radicle.**—Various attempts have een made to explain the ascent of the plumule, and the descent of ie radicle, but none of them are satisfactory. Physiologists have not een able to detect any law to which they can refer the phenomena, lthough certain agencies are obviously concerned in the effects. ome have said that the root is especially influenced by the attraction f the earth, while the stem is influenced by light. Experiments have own that the direction of the root is not owing to the moisture of e soil, and that the ascent of the stem is not due to the action of ht and air; for roots descend, and stems ascend, even when the er are placed in contact with the earth, and the former submitted he action of light. Knight thinks that the direction of stem and s may be traced to gravitation, and the state of the tissues. When nch is horizontal, the fluids gravitate towards the lower side; a ous growth takes place there; the tissues enlarge, and, by sing more than those on the upper side, an incurvation is pro- , the convexity of which looks downwards, and thus the extremity branch is directed upwards. Again, in the root the increase lace by the extremity, and the fluids by their gravity cause this in always a descending direction. A similar explanation is by Dodart. Dutrochet refers the phenomena to endosmose, aries in its effects according to the comparative size of the cells centre and circumference of an axis. In young stems with th, the central cells are larger, and they diminish towards the rence; whereas in roots, according to him, the diminution ace in the reverse manner. Large cells distend more rapidly

Germination of the dicotyledonous aperispermic seed of Acacia Julibrissin. *e*, or testa. *r*, Radicle of the embryo. *t*, Tigellus or cauliculus. *c*, Cotyledons. *g*, plumule. 1. First stage: in which the radicle ruptures the envelope or spermoderm, externally at the micropyle. 2. Second stage: where the parts of the embryo are gaged from the covering, the summit of the cotyledons only being retained by the 3. Third stage: where the embryo is entirely disengaged from the envelope or and the cotyledons, *c c*, are separated so as to exhibit the plumule, *g*.

than small ones; and, according to their position in the axis, will thus cause curvature outwards or inwards, the largest occupying the convexity of the arch, the smallest the concavity. When a branch or root is laid horizontally, the force of endosmose is weakened on the lower side, and, consequently, will cease to neutralise the tendency to incurvation on the upper side, which will therefore be directed either upwards or downwards, according to the position of its layers of small cells,—in the case of a branch with large central cells, curving upwards; and in the case of a root with larger hemispherical cells, downwards.

625. These explanations do not appear, however, to be altogether satisfactory. It is known that the stem is directed upwards, the root downwards, but, as yet, physiologists have not been able to ascertain the laws which regulate them. The tendencies of the root and stem are not easily counteracted. When a seed is planted in moist earth, and suspended in the air, the root will, in the progress of growth, leave the earth and descend into the air in a perpendicular direction, while the stem will pass through a quantity of moist earth in an upward direction. If their positions are reversed they will become twisted, so as to recover their natural positions.

626. The effect of light on the stem may be illustrated by the growth of plants in circumstances where a pencil of light only is admitted on one side. Dr Poggioli of Bologna was the first who observed the influence exercised by the rays of the spectrum in causing flexion of plants. Experiments on this subject have been made by Payen, Dutrochet, and Gardner. They consider the blue rays as those which have the greatest effect on the plumule. Hunter observed, that if a barrel filled with earth, in the centre of which are some beans, be rotated for several days horizontally, the roots pointed in a direction parallel to the axis of rotation Knight[*] put Mustard seeds and French beans on the circumference of two wheels, which were put in rapid motion, the one in a horizontal, and the other in a vertical manner; and he found that, in the former, the roots took a direction intermediate between that impressed by gravitation and by the centrifugal force, viz., downwards and outwards, while the stems were inclined upwards and inwards. In the latter, where the force of gravitation was neutralized by the constant change of position, the centrifugal force acted alone, by which the roots were directed outwards, at the same time that the stem grew inwards. To explain these results, there must be allowed—1. A more or less liquid condition of the new of the young plant. 2. A different density in the different parts latter. 3. A tendency of the denser parts of new plants, during ation, towards the root. On the vertical wheel, the parts of the plants submitted to the centrifugal force only, had their roots est parts at the circumference. On the horizontal, the effect

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[*] See Knight's Horticultural Papers, London, 1841, p. 124.

was intermediate between centrifugal force and gravity. The upper side of leaves is under the influence of light in a marked degree, for, when placed in the reverse position by the turning of a branch, they twist round so as to resume their natural exposure. During darkness, on the contrary, many leaves fold in such a way that their lower surface is exposed. Some plants grow indifferently in all directions at the period of germination. The Mistleto and other parasites direct their radicles towards the centre of the tree or plants to which they are attached, while the plumule grows perpendicularly to the surface.

627. **Monocotyledonous Germination.**—In Monocotyledons, there is generally a perisperm present, often in large quantity, and in them the cotyledon remains more or less within the seed at the period of germination. The intra-seminal portion of the cotyledons, as in Canna, and especially in the Coco-nut, becomes developed as a pale cellular mass, which increases much, and absorbs the nutriment required for the embryo. In some Monocotyledons the perisperm disappears entirely; in others, as in the Phytelephas or Ivory Palm, while certain soluble matters are removed, the perisperm still retains its original form. The intra-seminal part may be said to correspond to the limb or lamina of the cotyledonary leaf. The extra-seminal portion, corresponding to the petiole, becomes often much elongated, as in the double Coco-nut, and ends in a sheath which envelopes the axis or cauliculus, and the plumule. Sometimes, however, there is no marked elongation of the cotyledon, the sheath being at once formed on the outside of the seed, so that the plumule and radicle are, as it were, sessile on its surface. These phenomena are well seen in Canna indica (fig. 527), where *e* is the envelope of the seed; *p*, the perisperm or

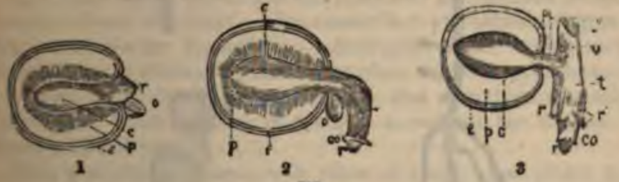

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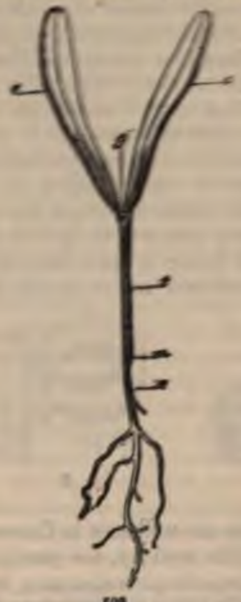
Fig. 527.—Germination of the monocotyledonous perispermic seed of Canna indica. The seed is cut to show the relation between the perisperm and the embryo at different stages, the former diminishing, while the latter increases. *e*, Envelope or spermoderm. *o*, Its upper part, which is separated like a lid or operculum, to allow the passage of the radicle. *p*, Perisperm or albumen. *c*, Cotyledon. *r*, Radicle or young root. r' r', Secondary radicles. *c o*, Coleorhiza or sheath of the roots. *f*, Slit indicating the position of the gemmule; at this slit an elongated sheath, *v*, is protruded. *p c*, Narrow portion of the cotyledon (corresponding to the petiolary portion), intermediate between its enlarged portion, *c*, (corresponding to the lamina or limb of the leaf), and its sheathing or vaginal portion, *v*. *t*, Tigellus or cauliculus. *g*, Gemmule or plumule. 1. First stage, in which the radicle, *r*, begins to appear through the integuments or spermoderm. 2. Second stage, where the slit, *f*, is seen also on the outer surface, indicating the situation of the gemmule. The true radicle, *r*, has pierced the envelope of the seed, and at its base shows a small sheath or coleorhiza. One of the small radicles, r', is also seen with a coleorhiza. 3. Third stage, when all the parts are more developed, and the gemmule, *g*, appears on the outside of the slit, *f*, the edges of which are prolonged in the form of a sheath or vagina, *v*.

albumen; *s*, the intra-seminal portion of the cotyledon, which absorbs the nourishment; *p c*, the petiolary or extra-seminal portion of the cotyledon, which varies in length, and may be wanting; *e*, the sheathing portion of the cotyledon, from a slit in which, *f*, the plumule, *g*, protrudes, supported on the axis or cauliculus, *t*; while the radicles, *r* and *r′*, pierce the integument at the base, and are each covered with a separate sheath, *c o*, called coleorhiza (fig. 124). In aperispermic Monocotyledons, as Alismaceæ and Potameæ (fig. 506), the cotyledon does not remain within the seed, but is raised above the ground, *c*, giving origin to the plumule, *g*, which is at first enclosed in its sheath.

628. Thus the cotyledon follows the development of leaves. Its limb is first produced, and is either pushed above ground, or is confined within the seed. In the latter case it is arrested in its progress; subsequently, a sheath is formed which may either be a direct continuation of the limb, or may be separated from it by a petiolary



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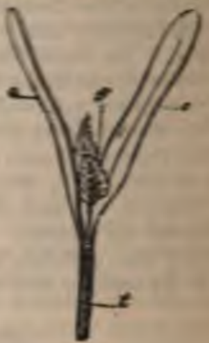

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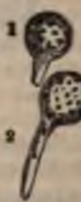

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Fig. 528.—Germination of the dicotyledonous embryo of Acer Negundo. *m*, Collum, collar or neck. *r*, Root. *t*, Caulicule or stem. *c c*, Cotyledons. *g*, Gemmule or plumule.

Fig. 529.—Upper part of the same embryo more developed. *c c*, Cotyledons. *g*, Gemmule, the rst leaves of which are already expanded. *t*, Caulicule or stem.

ig. 530.—Acotyledonous embryos or spores of Marchantia polymorpha, germinating. 1. Spore he early stage of germination. 2. In a more advanced stage. The spores are simple cells ch elongate during germination at some point of their surface. They are [illegible] y may be compared to naked embryos rather than to seeds.

portion. When the limb is confined in the seed, and ceases to be developed, the sheath often continues to grow, forming a marked covering of the axis. The roots in Monocotyledons during germination (fig. 124 *r r*), pierce the radicular extremity of the embryo, and become covered with sheaths or coleorhizas, *c c*, formed by a superficial layer of cellular tissue. As the radicular extremity thus remains within the embryo, and sends out radicles from its surface, the plants are said to be *endorhizal* (ἔνδον, within, and ῥίζα, a root). See ¶ 127.

629. **Dicotyledonous Germination.**—In Dicotyledons, the cotyledons generally separate from the integuments, and either appear above ground in the form of temporary leaves (figs. 528, 529 *c c*), which differ in form from the permanent leaves of the plant (fig. 529 *g*), or remain below as fleshy lobes. In the former case they are *epigeal* (ἐπὶ, upon or above, and γία, the earth), in the latter case (as in Beans, Arachis, &c.), they are *hypogeal* (ὑπὸ, under). The cotyledons usually separate, but sometimes they are united, and appear as one. In all cases, the plumule (figs. 528, 529 *g*) proceeds from between the two cotyledons, and does not pierce through a sheath as in monocotyledons. The root (fig. 528 *r*) is a direct prolongation of the axis, *t*, in a downward direction, separating from it at the collar, *m*, and the embryo is here *exorhizal* (ἔξω, outwards). See ¶ 126.

In Acotyledons, the spore (fig. 530) has no separate embryo in its interior, but germinates from any part of the surface; hence it is called *heterorhizal* (ἕτερος, diverse). See ¶ 128. The spore may be considered as a cellular embryo rather than a seed.

630. Some seeds commence the process of germination before being detached from the plant. This occurs in a remarkable degree in the Mangrove trees, or Rhizophoras, which grow at the muddy mouths of rivers in warm climates. Coco-nuts often begin to germinate during a voyage from the tropics to Britain, and germinating seeds have been found in the interior of Gourds, as well as the fruit of Carica Papaya, the Papaw.

631. **Proliferous Plants.**—In place of seeds, some plants produce buds which can be detached and produce separate individuals. Flowers which are thus changed into separable buds, are called *proliferous* (*proles*, offspring, and *fero*, I bear), or *viviparous* (*vivus*, alive, and *pario*, I produce). They are met with in many alpine grasses, as Festuca ovina, *var.* vivipara, Aira cæspitosa, *var.* alpina, Poa alpina, &c., as well as in Alliums, Trifoliums, and Ferns. Buds of a similar kind may be produced on the edges, or in the axil of leaves, as in Byrophyllum calycinum, Malaxis paludosa, many species of Gesnera, Gloxinia, and Achimenes; and the bulbils of Lilium, Ixia, and Dentaria, seem to be peculiar forms of buds, capable of being detached, and of assuming independent growth. Buds, however, differ from embryos of seeds in the direction of the roots being towards the axis of the plant.

632. The length of time required for the protrusion of the radicle varies in different plants. Some seeds, as garden cresses, germinate in the course of twenty-four hours, others require many days or many months. Seeds with hard coverings, or a stony perisperm, may lie dormant in the soil for a year or more. The following experiments were made in the Geneva garden, on seeds similarly watered, and exposed to a medium temperature of 53° F. It was ascertained that one-half of the species of the following families germinated after the lapse of the number of days here mentioned:—

Amaranthaceæ,	9 days.
Cruciferæ,	10 —
Boraginaceæ, Caryophyllaceæ, Chenopodiaceæ, Malvaceæ,	11 —
Compositæ, Convolvulaceæ, Plantaginaceæ,	12 —
Polygonaceæ,	13 —
Campanulaceæ, Leguminosæ, Valerianaceæ,	14 —
Gramineæ, Labiatæ, Solanaceæ,	15 —
Rosaceæ,	17 —
Ranunculaceæ,	20 —
Antirrhineæ, Onagrariæ,	22 —
Umbelliferæ,	23 —

Temperature has a great effect in accelerating germination. Thus, Erigeron caucasicum, at a temperature varying from 49° to 53°, germinated in ten days; at a temperature from 66° to 72°, in two days; Dolichos abyssinicus, at the former temperature, in ten days, at the latter, in three; Zinnia coccinea, in twenty-two, and five days respectively.

633. **Duration of the Life of Plants.**—Plants, according to the duration of their existence, have been divided into *annual*, *biennial*, and *perennial*. The first of these terms imports that the seed germinates, and that the plant produces leaves and flowers, ripens its seed, and perishes within twelve months; the second, that a plant germinates and produces leaves the first year, but does not produce a flowering stem, nor ripen its seed, till the second, after which it perishes: while the third intimates, that the process of flowering and fruiting may be postponed till the third year, or any indefinite period. The first two exercise the function of flowering in general only once, while the last may do so several times before dying. Under different climates, however, and under different modes of management, the same species may be annual, biennial, or even perennial. Thus, Wheat in this country is annual if sown early in spring, but biennial if sown in autumn; in hot climates, Lolium perenne proves annual; the Castor-oil plant in this country is annual, while in Italy it is a shrub of several years' duration; the annual Mignonette, by removing its flower-buds the first year, and keeping it in a proper temperature during the winter, be rendered perennial and shrubby. Many flowering garden s, as Neapolitan Violet and Lily of the Valley, may be brought

into flower at a late period of the year, by pinching off the blossoms in the early part of the season.

634. Plants as regards their flowering and fruiting, have also been divided into *monocarpic* (μόνος, one, and καρπὸς, fruit), or those which flower once only and then die; and *polycarpic* (πολὺς, many), or those which flower and fruit several times before the entire plant dies. Thus, annuals and biennials, which flower the first or second year and die, as well as the Agave, and some Palms which flower only once in forty or fifty years, and perish, are monocarpic; while perennials are polycarpic. Some perennial woody plants live to a great age. Some specimens of Adansonia digitata, the Baobab of Senegal, are said to be more than 5000 years old. The Yew, the Oak, the Lime, the Cypress, the Olive, the Orange, Banyan, and Chestnut, often attain great longevity.

635. The following is a notice of the size and age of some trees:—

Height to which forest trees grow in France	120 to 130	feet.
Height to which forest trees grow in America	150 to 250	—
Height of specimens of Wellingtonia gigantea	450	—
Trunks of some Baobabs have a girth of	90	—
Trunk of Dracæna of the Canaries has a girth of	45	—
That of an Acer in South Carolina has a girth of	62	—
In France trees have often a girth of	25 to 30	—
Oaks in Britain planted before the Conquest, more than	800	years old
Yew at Fountain's Abbey, Ripon	1200	—
Yews in churchyard of Crowhurst, Surrey	1450	—
Yew at Fortingal, Perthshire	2500 to 2600	—
Yew at Hedsor, Bucks, 27 feet diameter	3200	—

A specimen of Ficus indica, or the Banyan, on an island in the river Nerbudda, is believed to be identical with one that existed in the time of Alexander the Great, and which, according to Nearchus, was then capable of overshadowing 10,000 men. Parts of it have been carried away by floods, but it can shade 7000 men, and the spread of its boughs, measuring its principal trunk only, is 2000 feet. The chief trunks of this tree greatly exceed our English Oaks and Elms in thickness, and are above 350 in number. The smaller stems are more than 3000 in number.

636. The Maronites believe that some Cedars near the village of Eden in Lebanon, are the remains of the forest which furnished Solomon with timber for the temple, full 3000 years ago. These Cedars were visited by Belonius in 1550, who found them twenty-eight in number; Rawolf, in 1575, makes them twenty-four; Dandini, in 1660, and Thevenot, about fifty years after, make them twenty-three; Maundrell, in 1696, found them reduced to sixteen; Pococke, in 1736, found fifteen standing; in 1810, Burckhardt counted eleven or twelve; and Dr. Richardson, in 1818, states them to be no more than seven. They must be of great *antiquity*, seeing they were counted

old 300 years ago. Maundrell mentions the size of some Cedars. The largest he measured was 36 feet 6 inches in ference, and 117 feet in the spread of its boughs.

637. Decandolle gives a list of the ascertained ages of trees:—

Elm	335	years.
Cypress, about	350	—
Cheirostemon (Hand-tree), about	400	—
Ivy	450	—
Larch	576	—
Sweet Chestnut, about	600	—
Orange	630	—
Olive	700	—
Platanus orientalis	720	—
Cedar	800	—
Many tropical trees, according to Humboldt, about	1000	—
Lime	1076, 1147	—
Oak	810, 1080, 1500	—
Yew	1214, 1458, 2588, 2820	—
Taxodium, upwards of	4000	—
Adansonia	5000	—
Wellingtonia (Torrey)	1120	

10.—GENERAL OBSERVATIONS ON THE ORGANS OF PLANTS, AND ON THE WHICH THEY ARE ARRANGED.

638. Before concluding the consideration of the elemen compound organs of plants, it is proposed to make som observations on their arrangement and development. The is a tabular view of the various organs to which attentio directed:—

GENERAL ARRANGEMENT OF THE ORGANS OF PHANEROGAMOU

I.—Elementary Organs.

Membrane……… { Vesicles or Cellules…… …………Cellular
Fibre……………… { Spiral Vessels or Tracheæ. } ……Vascul
{ Ducts or Tubes…………… }

II.—Compound Organs.

1. General Integument.

Cuticle or Pellicle…. }
Stomata……………. } ……Epidermis.
Hairs, Prickles or Ac

2. Nutritive Compound Organs.

Spongioles…. }
Fibrils……… } Roots.

Pith	Stem and Branches.	Rhizome.
Medullary Sheath		Tuber.
Heartwood or Duramen		Runner.
Sapwood or Alburnum		Sucker.
Medullary Rays or Plates		Corm.
Liber or Endophlœum		Bulb.
Cortical Layers or Epi- and Mesophlœum		Thorn.
Petiole	Leaf.	Phyllodia.
Limb or Lamina		Tendrils.
	Stipules.	Ascidia.

3. Reproductive Compound Organs.

	Bract.		Involucre.	
		Sepals—Calyx, Petals—Corolla,	Perianth or Perigone.	Flower.
Fovilla granules	Pollen grains,	Anther Filament	Stamens	
Carpels Ovules	Ovary, Style, Stigma,	Pistil		

4. Composition of Ripe Fruit.

		Pericarp.	Fruit.
Radicle Cotyledon Plumule	Embryo	Seed	
	Spermoderm		
	Albumen or Perisperm		

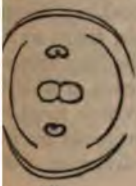
639. Plants may be said to be composed of numerous individuals, each having a sort of independent existence, and all contributing to the general growth of the compound individual formed by their union. In the case of a tree there are a vast number of buds, each of which is capable of being removed, and made to grow on another tree by grafting; and although each has thus a vitality of its own, it is nevertheless dependent on the general vitality of the tree, so long as it is attached to it. The same thing is seen in Sertularian Zoophytes. Each of the individuals forming a compound plant is called by Gaudichaud a *phyton* (φυτὸν, a plant), and in it he recognizes three parts or *merithalli* (μέρος, a part, and θαλλός, a frond), the *radicular merithal* corresponding to the root, the *cauline* to the stem, and the *foliar* to the leaf.

640. In the Acotyledonous plants, the embryo or spore consists of cells united together, and it is only during germination that it exhibits these different parts. In Monoctoyledons, the embryo consists of a single phyton, with a radicular merithal or radicle, a cauline or tigellus, and a foliar or cotyledon. In Dicotyledons, the embryo consists of two or more phytons united, with their foliar merithals (cotyledons) distinct, while their cauline and radicular merithals form each a single organ.

641. In tracing the various parts of plants, it has been shown that all may be referred to the leaf as a type. This morphological law was propounded by Linnæus and Wolff, but it is to Goethe we owe the full enunciation of it. Vegetable morphology, the study of forms, or the reference of the forms of the parts of plants to the leaf, is now the basis of organography, and it will be observed, that in considering the various organs, this has been kept constantly in view. The calyx, corolla, stamens, and pistil, are only modifications of the leaf adapted for peculiar functions. It is not meant that they were originally leaves, and were afterwards transformed; but that they are formed of the same elements, and arranged upon the same *plan*, and that in the changes which they undergo, and the relation which they bear to each other, they follow the same laws as leaves do. The different parts of the flower may be changed into each other, as into true leaves; or, in other words, the cellular papillæ from which they are formed are capable of being developed in different ways, according to laws which are still unknown. These changes may take place from without inwards, by an *ascending* or *direct metamorphosis*, as in the case of petals becoming stamens; or from within outwards, by *descending* or *retrograde metamorphosis*, as when stamens become petals.

642. Bracts are very evidently allied to leaves, both in their colour and form. Like leaves, too, they produce buds in their axil. The monstrosity called Hen and Chicken Daisy, depends on the development of buds in the axil of the leaves of the involucre. The sepals frequently present the appearance of true leaves, as in the Rose. The petals sometimes become green like leaves, as in a variety of Ranunculus Philonotis, mentioned by Decandolle, and in a variety of Campanula rapunculoides, noticed by Dumas. At other times they are changed into stamens. Decandolle mentions a variety of Capsella Bursa-pastoris, in which there were ten stamens produced in consequence of a transformation of petals. The stamens in double flowers are changed into petals, and in Nymphæa alba there is a gradual transition from the one to the other. Sometimes the stamens are changed into carpels, and bear ovules. This has been seen in Wallflower, some Willows, Poppy, &c. Petit-Thouars noticed a plant of House-leek, in which the one-half of the anthers bore ovules, and the other half pollen. The carpels, as in the double Cherry, may be seen in the form of folded leaves; in double flowers they are transformed into petals, and in other cases they are developed as stamens. It is said that increase of temperature, and luxuriance of growth, sometimes make flowers produce stamens only. In plants having unisexual flowers, this is more liable to take place, as in Melon, Cucumber, &c. Increased vigour seems to be required for the development of stamens, for some fir trees in their young state bear cones, and produce male flowers only when they reach the prime of life.

643. **Symmetry of Organs.**—In the progress of growth, the plants longing to the different divisions of the vegetable kingdom follow rtain organogenic laws (ὄργανον, an organ, and γεννάειν, to produce), e operation of which is seen in the definite arrangement of their gans. The flower consists sometimes of three, at other times of four five equal sets of organs, similarly and regularly disposed. Thus, he Iris has three straight parts of its perianth, and three reflexed ones lternately disposed, while the Fuchsia has four parts of the calyx lternating with four petals, and the Rose has five alternating portions. This orderly and similar distribution of a certain number of parts is alled *symmetry*, and flowers are thus said to be symmetrical with vari-us numbers of members. When the number of parts is two, the flower is *dimerous* (δὶς, twice, and μέρος, a part) (fig. 531), and the symmetry two-membered. When the number of parts is three, the flower is *trimerous* (τρεῖς, three), and when the parts are arranged in an alternating manner (fig. 532), the symmetry is *trigonal* or *triangular* (τρεῖς, three), and γωνία, an angle), as in the Lily. When there are four parts, the flower is *tetramerous* (τετρὰς, four), and the symmetry is *tetragonal* or *square* (figs. 533, 534), as in Galium and Paris. When there are five parts, the ower is *pentamerous* (πέντε, five), and the symmetry *pentagonal* (fig. 35), as in Ranunculus. The number of parts in the flower is indi-ated by the following symbols:—Dimerous $\sqrt[2]{}$ Trimerous $\sqrt[3]{}$ Tetra-erous $\sqrt[4]{}$ Pentamerous $\sqrt[5]{}$.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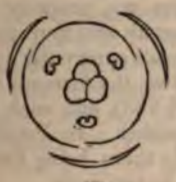
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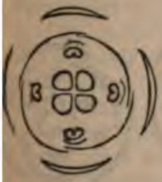
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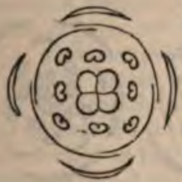
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644. There are also other kinds of arrangements in flowers, which ay be referred to certain modifications in the organogenic law. Thus, hat is called *oblong* or *two and two-membered* symmetry, occurs in ases where the opposite ends are similar, and the opposite sides as in he arrangement of the stamens of Cruciferæ. Again, *simple* symmetry that in which the two sides of the object are exactly alike, without

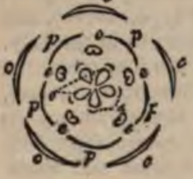
Fig. 531.—Diagram of the dimerous flower of Circæa Lutetiana, Enchanter's Nightshade. here are two carpels, two stamens, two divisions of the corolla, and two of the calyx. The ower is Isostemonous.

Fig. 532.—Diagram of the trimerous Isostemonous flower of Cneorum tricoccum. The floral velopes are arranged in sets of three, and so are the essential organs.

Fig. 533.—Diagram of the tetramerous Isostemonous flower of Zieria. The organs are ar-nged in verticils of four parts each.

Fig. 534.—Diagram of the tetramerous Diplostemonous flower of Ruta graveolens. There are ur carpels, eight stamens, or four in each verticil, four folioles of the calyx, and four petals

any further repetition, as in papilionaceous, personate, and labiate flowers, as well as in most leaves. The term symmetry, however, is properly confined to cases where the parts are arranged alternately, and are either equal or some multiple of each other, and has no reference to the forms of the different parts. In the very young state, the parts of the flower appear as a shallow rim, from which the petals and sepals arise as mammillæ, in a symmetrical manner. In the case of irregular corollas, the parts at first appear regular, as shown by Barneoud.* In speaking of flowers, it is usual to call them symmetrical when the sepals, petals, and stamens follow the law mentioned, even although the pistil may be abnormal. Thus, many Solanaceæ are pentamerous, and have a dimerous ovary, yet they are called symmetrical. In Cruciferæ, the flowers are, properly speaking, unsymmetrical, for while there are four sepals and four petals, there are six stamens in place of four. This depends apparently on the long stamens being in reality composed only of two, the filament of each of which is split by a process of chorization (¶ 383), and each division forms for itself by multiplication a perfect anther. In Papilionaceous flowers, the parts are usually symmetrical, there being five divisions of the calyx, five petals, and ten stamens in two rows.



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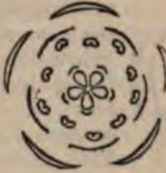
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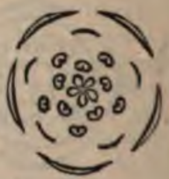
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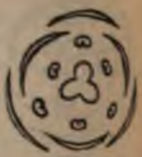
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645. It will be seen that flowers constituting trigonal or pentagonal symmetry, may present what has been called simple symmetry, when one of the petals or sepals becomes more developed than the others. In Dicotyledonous plants, it is common to meet with pentagonal (figs. 535, 536, 537) and tetragonal (figs. 533, 534), symmetry, the parts being arranged in fives and fours, or in multiples of these numbers. It is common to find the stamens more numerous than the petals, and in that case they are arranged in different verticils, each alternating

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* Annales des Sciences Naturelles, November, 1846.

Fig. 535.—Diagram of the pentamerous Isostemonous flower of Crassula rubens. *c c c c c*, Parts of the calyx. *p p p p p*, Petals alternating with the leaves of the calyx. *e e e e e*, Stamens alternating with the petals. *a*, Accessory bodies in the form of scales, or a disk alternating with the stamens. These scales are often an abortive row of stamens. *o*, Carpels alternating with the stamens, and opposite to the scales.

Fig. 536.—Diagram of the pentamerous flower of Sedum Telephium. The stamens are ten, arranged in two alternating verticils. The flower is Diplostemonous.

Fig. 537.—Diagram of the pentamerous Diplostemonous flower of Coriaria myrtifolia; the parts of the four whorls alternating, the verticil of stamens being double.

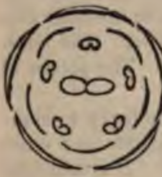
Fig. 538.—Diagram of the trimerous Diplostemonous flower of Ornithogalum pyrenaicum. Stamens six in two alternating verticils.

with that next it. Thus if there are five sepals, five petals, and twenty stamens, the latter are considered as forming four verticils. No doubt the verticils are often traced with difficulty, more especially when adhesions take place. In Monocotyledons (fig. 538), the parts are usually in sets of three, or in some multiple of that number, exhibiting trigonal symmetry. In Acotyledons, when any definite number can be traced, it is found to be two, or some multiple of two. The teeth of Mosses are in sets of four, or some multiple of four. The spores of many Acotyledons are also arranged in fours.

646. **Teratology.**—There has thus been traced a tendency to symmetrical arrangement in plants. But the parts of plants are often modified by natural causes which cannot be explained. It is assumed that each of the similar members of a flower have the same organization, and a similar power of development; and hence, if among these similar parts some are less developed than others, they are considered as *abortive*, and these abnormal states are traced to changes which take place in the earlier stages of growth. Such changes often interfere with the symmetry of the flower. Alteration in the symmetrical arrangement, as well as in the forms of the different parts of plants, have been traced to *suppression* or the *non-development* of organs, *degeneration* or imperfect formation, *adhesion* or union of one part to another, *multiplication* of parts, and *unlining* or *chorization*. The study of *Teratology* (τέρας, a monstrosity, and λόγος, treatise), or of the monstrosities occurring in plants, has led to many important conclusions relative to the development of organs, and it is only by tracing the parts of plants through all their stages and transformations, that correct ideas can be formed as to their relations and forms.

647. By *suppression* is meant the non-appearance of an organ at the place where it ought to appear if the structure was normal, the organ being wanting to complete the symmetry. This suppression is liable to occur in all the parts of plants, and gives rise to various abnormalities. Suppression may consist in the non-appearance of one or more parts of certain verticils, or of one or more entire verticils. In the flowers of Staphylea (fig. 539), there are five parts of the calyx, five petals, five stamens, and only two carpels; in many Caryophyllaceæ, as Polycarpon and Holosteum (fig. 540), while the calyx and corolla are pentamerous, there are only three or four stamens and three carpels; in Impatiens noli-me-tangere (fig. 541), the calyx is composed of three parts, while the other verticils have five; in Labiate flowers, there are five parts of the calyx and corolla, and only four stamens; and in Tropæolum pentaphyllum (fig. 542), there are five sepals, two petals, eight stamens, and three carpels. In all these cases, the want of symmetry is traced to the suppression of certain parts. In the last mentioned plant, the normal number is five, hence it is said that there are three petals suppressed, as shown by the position of the two

remaining ones (fig. 542); there are two rows of stamens, in each of which one is awanting, and there are two carpels suppressed. In many instances the parts which are afterwards suppressed can be seen in the early stages of growth, and occasionally some vestiges of them remain in the fully developed flower. Sometimes the whorl of the petals is awanting, the flowers being *apetalous* (α, privative, and πέταλον, a leaf) (fig. 543), and in such cases it is common to see the stamens opposite to the segments of the calyx, as in Chenopodiaceæ (fig. 544). That this suppression of the petals takes place is shown in the case of certain allied plants, as in the natural orders Caryophyllaceæ and Paronychiaceæ, where some species have petals and others want them.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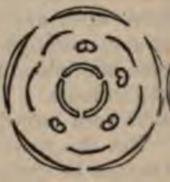
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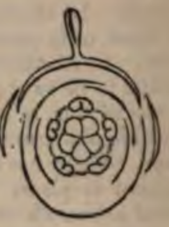
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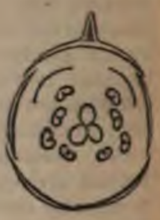
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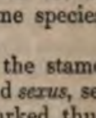
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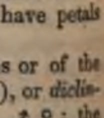
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648. By the suppression of the verticil of the stamens or of the carpels, flowers become *unisexual* (*unus*, one, and *sexus*, sex), or *diclinous* (δὶς, twice, and κλίνη, a bed), and are marked thus, ♂ ♀; the first of these symbols indicating the male, and the second the female flower. Thus, in Jatropha Curcas (fig. 314), the flowers have five segments of the calyx, and five petals, while in some (fig. 314, 1) the pistil is awanting; in others (fig. 314, 2), the stamens. In the genus

Fig. 539.—Diagram of the flower of Staphylea pinnata. The parts of the calyx, corolla, and stamens are pentamerous, while the pistil, in consequence of the suppression of three carpels, is dimerous.

Fig. 540.—Diagram of the flower of Holosteum umbellatum. There are five calycine divisions and five petals; but the stamens, by the suppression of one, are only four in number; while the carpels are, by suppression, reduced to three. Thus the flower is unsymmetrical.

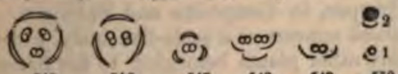
Fig. 541.—Diagram of the flower of Impatiens parviflora, with one of the calycine leaves spurred. There are five carpels, five stamens, five petals, one of which is larger than the rest, but only three parts of the calyx, in consequence of suppression.

Fig. 542.—Diagram of the flower of Tropæolum pentaphyllum, with a spurred or calcarate calycine leaf. The petals, by suppression, are reduced to two; the stamens are eight in place of ten, and the carpels three in place of five.

Fig. 543.—Diagram of the flower of Glaux maritima, showing the suppression of the verticil of the corolla. There are five divisions of the calyx, five stamens alternating with them, and five divisions of the ovary, with a central placentation.

Fig. 544.—Diagram of the flower of Chenopodium album, showing the suppression of the verticil of the corolla. The five stamens, in this case, are opposite to the divisions of the calyx, thus exhibiting the arrangement which might be expected from a non-development of the corolla. divisions of the ovary are not easily seen, the placentation being central.

there are usually stamens and pistil present, or the flower is
rodite, or *monoclinous* (μόνος, one, and κλίνη, a bed); but in
lioica, some flowers have stamens only; others pistils only.
that *monoecious* and *dioecious* (μόνος, one, δὶς, twice, and οἰκίον,
ion) plants are produced by the suppression of the essential
the flowers, either of the same or of different individuals of
species; while *polygamous* (πολὺς, many, and γάμος, mar-
nts are those in which, besides unisexual, there are also her-
ite or perfect flowers.
ome parts of the pistil are generally suppressed in the pro-
growth, and hence it is rare to find it symmetrical with the
orls. When the fruit was treated of (¶ 522), it was shown
pels and ovules often become abortive by pressure and
n, so that the pericarp and seeds differ in their divisions
bers from the ovary and ovules. If the whorls of the calyx
lla are awanting, the flower becomes *naked* or *achlamydeous*
It may still, however, be fitted for the functions of producing
t if the essential organs, viz., the verticils of stamens and
e suppressed, then the flower, however showy as regards its
, is unfit for its functions, and is called *neuter*. Flowers hav-
ens only, are *staminiferous*, *staminal*, *sterile*; those having
ly, are *pistilliferous*, *pistillate*, or *fertile*. The suppression of



545 546 547 548 549 550

erticils, and parts of them, is well seen in the family of the
iaceæ (figs. 545—550). Thus, in fig. 545 is delineated an
trimerous staminal flower; in fig. 546 one of the stamens is
d, and in fig. 547 two of them are awanting. Again, in figs.
, 550, the calyx is suppressed, and its place occupied by one,
three bracts (so that the flower is, properly speaking, achla-
), and only one or two stamens produced. In fig. 550, 1,
a sterile flower, consisting of a single stamen with a bract;
g. 552, 2, a fertile flower, consisting of a single carpel with a

—550.—Diagrams of flowers of Euphorbiaceous plants, becoming more and more
) The calyx is the only envelope, and consists of three parts in figs. 545, 546, and 547.
tely suppressed in figs. 548, 549, and 550, and its place is occupied by a bract, in the
h the flower is produced; this bract being accompanied in figs 548 and 549 with two
ets. (2.) The male flowers in fig. 545 have three stamens, in figs. 546 and 548 they
figs. 547 and 549 one stamen only is developed, and in fig. 550, 1, the solitary stamen
anther-lobe. (3.) The female flower in fig. 550, 2, is reduced to a single carpel, with
he axil of which it is produced.
-Diagram of a staminiferous flower of Tragia cannabina.
-Diagram of a staminiferous flower of Tragia volubilis.
-Diagram of a staminiferous flower of Anthostema senegalense.
-Diagram of a staminiferous flower of Adenopeltis colliguaya.
-Diagram of a staminiferous flower of a Euphorbia.
-1. Diagram of a staminiferous flower of Naias minor. 2. Of a pistilliferous flower of

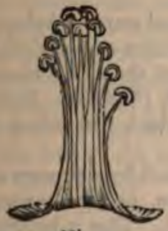
bract. There is thus traced a *degradation*, as it is called, from a flower with three stamens and three divisions of the calyx, to one with a single bract and a single stamen or carpel.

650. It is common to find some of the buds of a plant suppressed, thus altering the spiral arrangement. Such buds, however, are often capable of being developed, if any accident occurs, or if the plant is pruned. Deficiency of light and of air, and want of proper nourishment, are capable of producing abortions of various kinds. The non-development of a branch gives rise to *clustered* or *fascicled* (*fascis*, a bundle of twigs) leaves, as in the Larch, and to fascicled twigs, as in a common bird-nest-like monstrosity of the Birch. When the true leaves of a plant are suppressed, their place may be occupied by a tendril, as in Lathyrus Aphaca, in which the stipules perform the functions of leaves (¶ 201); or the petiole may be developed in a peculiar way, as in the phyllodia (¶ 157) of some Acacias.

651. *Degeneration*, or the transformation of parts, often gives rise either to an apparent want of symmetry, or to irregularity in form. Branches, when not properly developed, may assume the form of thorns or spines (¶ 200), as in the Hawthorn and Wild-plum; and by culture these spines may be converted into leaf-bearing branches. Leaves often become mere scales, as in Lathræa, Orobanche, and in Bulbs. The limb of the calyx may appear as a rim, as in some Umbelliferæ; or as pappus, in Compositæ and Valeriana. In Scrophularia, the fifth stamen appears as a scale-like body, called *staminodium* (fig. 346); in many other plants belonging to the Scrophulariaceæ, it assumes the form of a filament, with hairs at its apex in place of an anther. In unisexual flowers, it is not uncommon to find vestiges of the undeveloped stamens in the form of filiform bodies or scales. To many of these staminal degenerations, Linnæus gave the name of *nectaries*. In double flowers, transformations of the stamens and pistils take place, so that they appear as petals. In Cannæ, what are called petals are in reality metamorphosed stamens. Allusion has already been made to the various changes which the different parts of the flower thus undergo. The object of the florist is to produce such monstrosities; and flowers, which by him are considered perfect, are looked upon by the botanist as imperfect, from the want of the essential organs.

652. *Adhesion*, or the growing together of parts, is a very common casue of changes both as regards form and symmetry. The union of stems gives rise occasionally to anomalies, as in the *fasciated* stalk of Cockscomb (fig. 230), and the flattened stems of some Coniferæ (¶ 197), and probably also the peculiar stems of certain Sapindaceæ and Menispermaceæ of Brazil (¶ 90). Some of these, however, may perhaps be traced not to adhesion, but to an abnormal development of buds, producing wood only in one direction in place of all round.

Natural grafts occasionally occur from one branch of a tree uniting to another. Roots also sometimes become grafted, and to this has been attributed the vitality occasionally preserved by the stumps of Spruce-firs which have been felled on the Swiss Alps. The union of two leaves by their base, forms a connate leaf, and the adhesion of the lobes of a single leaf on the opposite side of the stalk, gives rise to perfoliate leaves (fig. 156). The union of the edges of a folded leaf forms Ascidia, or pitchers (figs. 184, 187). The different parts of the same verticil of the flower unite often more or less completely, giving rise to a monophyllous or gamophyllous involucre (¶ 347); a monosepalous or gamosepalous calyx (fig. 273); a monopetalous or gamopetalous corolla (figs. 293, 294, &c.); monadelphous (figs. 307, 314, 1), diadelphous (¶ 399), and polyadelphous (figs. 315, 551) stamens; syngenesious anthers (¶ 417); a gynandrous column (¶ 400), and a syncarpous ovary (fig. 383). The different verticils of the flower are frequently adherent. The calyx is often united to the corolla or to the stamens, or both (fig. 308); the stamens may adhere to the corolla (fig. 552); or there may be a union of the four verticils of the flower, so that the calyx becomes superior (fig. 309). In some instances, when the axis is elongated, adhesions take place between it and certain whorls of the flower. Thus, in some Caryophyllaceæ (fig. 553), the calyx, *c*, bearing the stamens, *e*, and petals, *p*, becomes united to the axis, *g*, which supports the ovary, *o*. In Capparidaceæ (fig. 554), the calyx, *c*, and petals, *p*, occupy their usual position, but the axis is prolonged in the form of a gynophore, *ag*, to which the stamens, *e*, are united. Occasionally, contiguous flowers may unite, giving rise to double fruits, as is sometimes seen in Apples, Grapes, and Cucumbers.



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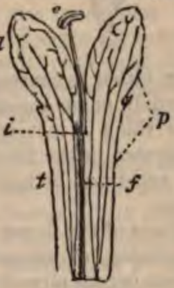

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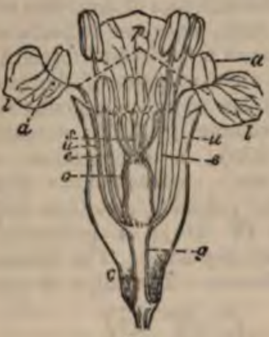
653. *Multiplication*, or an increase of the number of parts, gives rise

Fig. 551.—One of the five bundles of stamens taken from the polyadelphous flower of Malva miniata. Stamens are united by their filaments.

Fig. 552.—Portion of the gamopetalous or monopetalous corolla, *p*, of a Collomia, showing part of the tube, *t*, terminated by two lobes of the limb, *l*, and having the stamen, *e*, inserted into it, and united to it, so that the upper part of the filament, *i*, only is free.

to changes in plants. It is often found, that in plants belonging t
same natural order, the number of stamens in one is greater than



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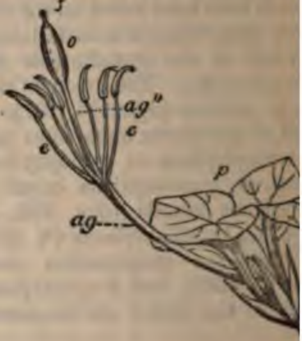


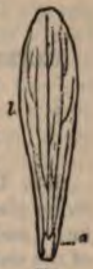
554

in another, either in consequence of additional stamens being deve
in the verticil, or on account of the production of additional ver
The same thing is met with in the case of the other whorls, a
well illustrated in the formation of the disk (¶ 428). Multipli
causes a repetition of successive whorls, which still follow the l
alternation.

654. Parts of the flower are often increased by a process of *de*
cation, *unlining*, *dilamination*, or *chorization*, *i.e.* the separation
lamina from organs already formed (¶ 383). This is believed t
place in a remarkable degree in the case of appendages to p
Thus, in Ranunculus, the petal (fig. 555) has a scale at its b
which is looked upon as a mere fold of it. This fold may in
cases be more highly developed, as in Caryophyllaceæ, and in
sula rubens (fig. 258 *a*), and it may even assume the charact
a stamen, which will therefore be opposite the petal, as in P
laceæ. Some do not consider the production of scales or st
opposite to the petals, as the result of chorization. Lindley a
against it from what is observed in Camellia japonica, in whic
petals are usually alternate; but, by cultivation, the law of alter
is interfered with, and the parts are so developed that the peta

Fig. 553.—Flower of Lychnis Viscaria, one of the Caryophyllaceæ, cut lengthwise, to s
relation of its different parts. *c*, Gamosepalous calyx. *p*, Petals with their elongated u
claw, *u u*, their limb, *l l*, and the appendages, *a a*, in the form of dilaminated scales of th
e e, Stamens. Pistil consists of the ovary, *o*, and five styles, *s*. *g*, Prolongation of the ax
form of a gynophore, or anthophore bearing the petals, the stamens, and the pistil.

Fig. 554.—Flower of Gynandropsis palmipes, one of the Capparidaceæ. *c*, Calyx. *p*
e, Stamens. *a g'*, Gynophore or elongated internode or axis bearing the stamens. *a g*
phore or elongated internode bearing the pistil. *o f*, Pistil composed of an ovary, *o*, a s
a stigma, *f*.



555

d run in several regular lines, from the centre nference. Again, by this process of chorization, may give rise to several. Thus, in Luhea pani- 316, 1), in place of five stamens there are five . 316, 2), composed partly of sterile filaments, *f s*, of filaments bearing anthers, *f a*; and each of s is traced to a deduplication of a single stamen, they arise from one point, and do not follow the nation. Thus, dilamination repeats the single causes opposition of parts. In the case of the mens of Cruciferæ (¶ 644), chorization is said to y a splitting of the filaments of two stamens; and o stamens on each side are, by *geminatiou* (*gemini*, twins), ie. This view is confirmed by cases in which the fila- e long stamens are more or less united; also, by cases in horter filaments exhibit tooth-like processes on either side, onger ones have them only on the outer side. In such o long filaments, if united, would present the same appear- shorter ones, and occupy their usual position of alternation tals. In some instances, by *pelorization* (πελώριος, mon- s found that tetradynamous plants become tetrandrous tamens alternating with the petals.

tivation has a great effect in causing changes in the various its. Many alterations in form, size, number, and adhesion due to the art of the horticulturist. The development issue and of starchy matter is often thus much increased, seen in the case of Turnips, Carrots, and Potato. The of the leaves of the Cabbage and Lettuce, and the forma- *rt*, as it is called, is due to cultivation; so also the curled voys, Cress, Endive, &c. The changes in the colour and owers thus produced are endless. In the Dahlia, the endered quilled, and are made to assume many glowing Pelargonium, the flowers have been rendered larger and ; and such is also the case with the Ranunculus, the Au- he Carnation. Some flowers, with spurred petals in their as Columbine, are changed so that the spurs disappear; as Linaria, in which one petal only is usually spurred, are to have all the petals spurred.

l of Ranunculus Ficaria, viewed on the inside. *l*, The limb. *a*, Small scaly base formed by chorization or dilamination.

SECTION IV.—SOME GENERAL PHENOMENA CONNECTED WITH VEGETATION.

1.—Vegetable Irritability.

656. Under this head are included certain sensible movements of living plants, exercised without any direct application of mechanical force, and not referable to mere elasticity, or the hygroscopic nature of the tissues. These motions are influenced chiefly by light and heat, and, like many phenomena occurring in organized beings, they cannot at present be explained by chemical or mere mechanical laws. They may, however, be excited by stimuli of a chemical or mechanical nature. Although the cause of them is obscure, still, in some instances, their use is obvious.

657. Among the lowest classes of plants there are some peculiar movements of this kind. The simplest members of the Sea-weed tribe occasionally move throughout their whole substance. Oscillatorias, which are filaments composed of cells placed end to end, containing fluid and granular matter, have an undulating movement, by means of which they advance. When placed in fluids under the field of the microscope, some of them may thus be seen to pass from one side to the other. The filaments sometimes twist up in a spiral manner, and then project themselves forward by straightening again. The motions are influenced by temperature and light, and by some are considered as being connected with the production of new cells. The spores of many Cryptogamic plants, especially species of Vaucheria, Conferva, and Prolifera, exhibit motions which, according to Thuret and Decaisne, depend on the presence of cellular hair-like processes, called *cilia* or *tentacula*. These motive organs are in a state of constant agitation, which lasts for some hours, becoming slower, and finally ceasing after germination has commenced. In the spores of Conferva glomerata and rivularis (fig. 431), there are two of these cilia or filiform tentacula, which project from a colourless rostrum. In Chætophora elegans, *var.* fusiformis, four have been seen (fig. 432); in Prolifera (fig. 433), there is a circle of cilia, and in Vaucheria (fig. 434), the spore is entirely covered with very short cilia, the vibration of which determines their forward movement. These spores, from their movements, have received the name of Zoospores (¶ 492). Mr. Thwaites accounts for the rhythmical movements of cilia by electrical currents. In certain cells of Cryptogamic plants, especially in what are called Antheridia, bodies are met with called Phytozoa or Spermatozoids (¶ 491), which also exhibit movements during a part of their existence.

658. Remarkable movements have also been observed in the higher

cs of plants. The fovilla contained in the pollen-grain in a young
, when moistened with water, exhibits movements when viewed
r the microscope. These movements have by some been referred
ritability, but by Brown and other accurate observers, they are
idered as merely molecular, and similar to what takes place between
minute particles of inorganic matter — as, for instance, finely
lered Gamboge suspended in water. These fovilla movements are
y seen in the very young pollen of Antirrhinum majus. Certain
ements also take place in the floral envelopes. Thus many flowers
and close at particular periods (¶ 483—485); these phenomena
nding on light, temperature, and moisture. Leaves also, especially
which are compound, are folded at certain periods in a distinct
uniform manner. What was called by Linnæus *the sleep of plants*,
e change produced on leaves by the absence of light. It is by no
ns analogous to the sleep of animals. During darkness some are
tly twisted and hang down; others, such as pinnate and ternate
s, have the leaflets folded together, and frequently the common
le depressed. The youngest leaflets first exhibit these changes;
when the plants become old, and their tissues hardened, the
bility is often much diminished, as is seen in Oxalises. The fold-
of the leaflets of compound leaves usually takes place from below
ards, but sometimes in the reverse manner, as in Tephrosia
bæa; so also with the common petiole, which is directed upwards
ng sleep in the Cassias, and downwards in Amorpha. When be-
the common petiole there are partial petioles, as in the Sensitive
t, they may be bent inwards towards each other, while the former
nt downwards.

9. Mimosa sensitiva and pudica, commonly called *sensitive plants*,
ay these movements of their leaves in a remarkable degree, not
under the influence of light and darkness, but also under
anical and other stimuli. They have bipinnate leaves with four
al petioles proceeding from a common rachis, and each of the
les is furnished with numerous pairs (about twenty) of leaflets,
h are expanded horizontally during the day. During darkness,
hen touched or irritated in any way, each leaflet moves upwards
rds its fellow of the opposite side, which in its turn rises up, so
their upper surfaces come into contact. When the movement
nences at the apex of the leaf, it usually proceeds downwards to
base, and thence may be communicated to the leaflets of the next
ial petiole, and ultimately to the common petiole, which falls down
rds the stem. The partial petioles then converge towards each
r, and have a tendency to become parallel to the common petiole,
he extremity of which they are suspended. When the plant is
en as by the wind, all the leaflets close simultaneously, and the
les drop together. If, however, the agitation is long continued,

the plant seems as it were to become accustomed to the shock, and the leaflets will expand again. The stem itself is not concerned in the movements. It may be cut and wounded cautiously without causing any change in the leaves, and a portion of it may be removed with a leaf attached, and still remaining expanded. If, however, a mineral acid is applied to the stem, after some time the petioles will fall and the leaflets collapse—the leaves perishing with the stem which has been moistened. The chemical action of the acid and absorption cause these phenomena. When a sensitive plant is exposed to artificial light during the night, Decandolle found that its leaves expanded, and that they closed when put into a dark room during the day, showing the influence which light has on these phenomena. It is to be remarked, however, that if the plant is kept for a long period of time in darkness, it will ultimately expand its leaves, and the phenomena of folding and opening will go on, although at very irregular intervals.

660. The ternate leaves of many species of Oxalis fold not merely during darkness, but also when agitated or struck lightly and repeatedly. Each of the leaflets folds upon itself, and then bends downwards upon the common petiole. The plant called Desmodium gyrans, the moving plant of India, has compound leaves consisting of a large terminal leaflet, and usually two smaller lateral ones. The latter are in constant movement, being elevated by a succession of little jerks, until they come into contact, and sometimes even slightly cross each other; after remaining in this position for a short time, they separate from each other, and move downwards by rapid jerks on opposite sides of the petiole. This process is constantly repeated, and goes on in a greater or less degree, both during day and night, but is most vigorous during warm moist weather. The large terminal leaflet undergoes movements also, oscillating very gradually from one side to the other, and becoming horizontal or depressed. By the lateral oscillatory movement, the leaf becomes inclined in various ways, often assuming a remarkable oblique direction. The upward and downward movements seem to depend on the influence of light and darkness. During the day the leaf becomes more or less horizontal, while during darkness it hangs down. Similar movements are seen in other species of Desmodium, as D. gyroides and vespertilionis.

661. The movements in these cases have, by Martius and Meyen, been referred to the presence of some structure analogous to the nervous system in animals. There is, however, no evidence of such a structure in plants, and these authors have not pretended to prove its existence. It is to be remarked, that the movements differ in many respects from animal contractility. They are usually *hinge* movements, and may be referred to certain changes in the organs, causing distention or contraction of these tissues. Dutrochet and Morren refer them to alterations in the circulation of fluids and air in the vessels

and cells. In plants with irritable leaves, there are frequently swellings where the leaflets join the stalk, as well as where the stalk joins the stem. These swellings contain cells which differ in their dimensions and their contents, and the movements are considered as being produced by changes in the contents of the cells, some of which become more distended than others, and thus cause incurvation or folding. In these swellings the vascular bundles are disposed in a circle near the periphery, and may be concerned in the movements. Mechanical and chemical stimuli are supposed to act by inducing alterations in the contents of the vessels and cells.

662. In the case of the sensitive plant, if the swelling at the base of the common petiole is touched even slightly on its lower side, it is followed by instant depression of the whole leaf, but no such effect is produced if the upper portion of the swelling is lightly touched. Again, touching the little swelling at the base of each leaflet on its upper side, causes the upward movement of the leaflet, but no such effect follows cautious touching of the lower part of the swelling only. If a pair of leaflets is touched at the extremity of a petiole, the irritation is usually continued downwards from apex to base; but if a pair at the base are touched, the progress of folding is reversed. Clear warm weather, with a certain degree of moisture, seem to be the conditions most favourable for these movements. They are seen best in young plants. The leaves of the sensitive plant contract under the action of electricity and galvanism. Some suppose, that in the sensitive plant there are two kinds of cells connected with the upper and lower sides of the leaves and petioles; the one set being contractile, and causing the closing of the leaflet and the fall of the petiole, the other being acted on chiefly through the circulation. In the case of the petiole, it is conceived that the tissue on the lower side of the swellings is contractile, while that in the upper is distensible. The turgescence of the latter, which is kept up by light, counteracts the contractility of the former, and maintains an equilibrium, so as to keep the petiole erect; but when acted on by cold, mechanical irritation, &c., the equilibrium is disturbed, and the contractility operates in depressing the petiole. A careful microscopic dissection of the swellings, shows peculiar cells in some parts, which seem to differ in their contents from others in their vicinity.

663. In the sensitive species of the Desmodium and Oxalis, the movements are not so evidently influenced by mechanical irritation. In the former, the little leaflets are supported on swollen petiolules, and it is to the curvation and twisting of these in different directions, that the movements seem to be owing. The leaflets remain flat and do not fold on themselves. It is said that by arresting the vital actions going on in the leaflets, by giving them a coating of gum, and thus preventing transpiration and respiration, the movements are

stopped, and that they recommence when the gum is removed by water. Cutting a leaflet across, and only leaving a small portion of its lamina attached to the petiolule, does not immediately stop the movement of gyration. In such a case, however, the motion ultimately ceases, while it continues in the uncut leaflet. So also, if a leaflet is divided longitudinally into two parts, each of them continues to move for a time, but the motions cease as the process of desiccation goes on.

664. There are occasionally cellular prolongations from the leaf, which, when touched, cause folding. Thus, in Dionæa muscipula, or Venus's fly trap, the lamina is articulated to the petiole, and consists of two free portions which are united together by a joint along the midrib. On the upper side of each part of the lamina are situated three hairs with swellings at the base, and when these hairs are touched, the halves approach each other from below upwards, so as to enclose any object, as a fly, which may happen to light on them. Similar movements, but in a much less obvious manner, are said to take place in the leaves of Droseras or Sun-dews. The movements are attributed to the same causes as those already mentioned, but the ultimate object is not known.

665. Movements take place in some parts of the flower, occasionally with the view of scattering the pollen on the stigma. The stamens of various species of Berberis and Mahonia are articulated to the torus or thalamus, and when touched at their inner and lower part, move towards the pistil. In Parnassia palustris, the stamens move towards the pistil in succession to discharge their contents. The Helianthemum vulgare or common Rock-rose, exhibits staminal movements also connected with the bursting of the anthers. Morren has noticed sensitiveness in the andrœcium of Sparmannia africana and Cereus grandiflorus. In the Nettle and Pellitory, the filaments are confined in a peculiar way by the perianth, and at a certain period of growth they are released so as to allow their elasticity to come into play, by means of which the pollen is forcibly scattered (¶ 497). In Goldfussia or Ruellia anisophylla, the style has a curved stigmatic apex, which gradually becomes straightened, so as to come into contact with the hairs of the corolla, upon which the pollen has been scattered; and in Mimulus and Bignonia (fig. 406), the stigma has two expanded lobes which close when touched, a movement apparently in some way connected with fertilization. In the Passion-flower, and some Cacti, the styles move towards the stamens. The species of Stylidium have the filaments and styles united in a common column, at the upper part of which the anther-lobes and stigma are placed. The column often projects beyond the flower, and is jointed. At the articulation an irritable swelling occurs, which when touched or acted upon by heat and light, causes a sudden incurvation by which the column is thrown to the opposite side of the flower, bursting the anthers and scattering

the central stigma. After a time the column recovers
These movements take place in the flower for some time
een removed from the plant and kept in water (¶ 497).
s in some flowers, as in Orchidaceæ, are said to move.
es this in the case of species of Megaclinium and Pteros-
ana sedifolia closes its petals when touched. Drakæa
an River terrestrial Orchid, is remarkable for the irrita-
stalk of the labellum. This stalk exhibits a moveable
elbow.

nical agents have an effect on the movements of plants.
causing irritation, others by destroying irritability. Nar-
, as opium, belladonna, and hydrocyanic acid, either
the roots or applied externally, destroy the irritability of
y cause closure of the leaves of the sensitive plant, and
ensible to the action of stimuli. Their prolonged action
, but if they are applied in moderate quantity, the plant
; and again unfold its leaflets. It frequently happens,
t the irritability continues for some time much impaired;
anical stimuli do not act in the same rapid and energetic
first. Similar effects are produced by ether and chloro-
ensitive plants are introduced into an atmosphere through
substances are diffused. The effects may be produced
pplying the vapour only to certain parts of the plant.
on the action of poisonous agents, both in the fluid and
e, have been performed by Marcet, Christison, Turner,
¶ 292—296).*

2.—TEMPERATURE OF PLANTS.

heat developed during the expansion of flowers and the pre-
he pollen, especially in the case of Aroideæ, and also at the
rmination, has been already considered (¶ 475, 476, &c.)
mena appear to be strictly of a chemical nature, and may
the absorption of oxygen, and its combination with the
ne starch, the latter being converted into dextrine and
It is now proposed to consider the observations which
ade relative to the general temperature of plants.

at differences of opinion have prevailed as to the existence
heat in plants. Hunter examined the heat of the inter-
the trunks of trees by boring holes of different depths in
serting thermometers; and similar experiments were made
at Tubingen. The results of these experiments were,

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bservations on Irritability, see Dutrochet, Recherches Anat. et Physiol. sur la
des Animaux et Vegetaux, 1844. Morren on the movements of the leaves of
ovement of the style of Goldfussia anisophylla, and of the column of Stylidium,
. Roy. de Bruxelles, tom. iv. v. vi. and xii. Thuret and Decaisne on the move-
in Annales des Sciences Naturelles, 2d Ser. xix. 3d Ser. xiv.

growing parts of plants. He found, by means of a ther
apparatus, that this varied from two or three-tenths of a
one degree above that of the air. This generation of heat
place when the plant is active and vigorous, and seems to b
with processes going on in the interior of the cells. Wh
cease to be actively engaged in the processes of vegetabl
cease to manifest this vital heat. It reaches a daily ma
period of which varies in different plants, according to th
Rameaux has confirmed Dutrochet's observations. He ob
during the day, the temperature of the various layers dimin
the surface to the centre, while during the night the reverse
and that both of these processes were materially influen
nature of the surrounding temperature and the diameter c
There appear, therefore, to be two sources of heat in plan
pending on organic actions carried on in the growing par
other on meteorological influences, which either act direct
the air, or indirectly through the fluid matters brought
certain depth in the earth.*

3.—LUMINOSITY OF PLANTS.

669. Luminous appearances have been observed in cert
These have been long noticed in the lower classes of plan
Fungi. Decaying wood, in which Fungi are developed, is
luminous. Mr. James Drummond describes some species
near the Swan River, growing on the trunks of Banksias
trees, which emitted at night a phosphorescent light su
enable him to read. A phosphorescent Agaric, with the
face of the pileus black, while the centre and gills were

Rhizomorphous fungi have long been celebrated for the light which they emit. The spawn of the Truffle (Tuber cibarium) is said to present similar appearances. It has been said that the luminosity of these fungi, as well as of decaying wood, is increased by exposure to oxygen gas. Some consider it as connected with the absorption of oxygen, being in reality a slow spontaneous combustion; while, according to others, it is referable to the liberation of phosphorus from some of its combinations in the plant.

670. These luminous appearances are said not to be confined to fungi. The younger Linnæus states, that the flowers of Nasturtium, Orange Lily, and African Marigold, at the end of a hot summer day, give out intermittent light. Mr. Dowden and Mr. James confirmed this by observations on the common Marigold and Papaver pilosum; while other observers have noticed the phenomena in the Sun-flower, French Marigold, species of Œnothera, and Arum. It is to be remarked, that the flowers said to be thus luminous, are all of a more or less orange colour, and that the phenomenon takes place in still warm summer evenings, towards twilight. Hence, Professor Allman is disposed to attribute them to optical illusions, depending on a peculiar intermittent effect on the retina. Some authors mention the occurrence of luminous sap in plants with milky juices, as the Euphorbia phosphorea of Brazil. A rhizome of an endogenous plant from India, is said, when moistened, to acquire a phosphorescent appearance, and to lose this property when dry.

4.—Colours of Plants.

671. Colour is not of much importance in Botany as regards classification and arrangement. It is chiefly in the case of Fungi that it is employed as a means of diagnosis. Perhaps the want of an accurate nomenclature of colours in Botany may have in part led to this. Mirbel and Henslow have proposed a nomenclature, which consists in referring all natural colours to certain absolute tints and shades, determined according to fixed laws. Thus, the latter assumes three primaries, as red, blue, and yellow, which together give white light, and derives all others from admixtures of these in definite proportions. On this principle he has constructed a chromatometer (χρῶμα, colour, and μέτρον, a measure), or measure of colour, the employment of which would lead to an accurate nomenclature.

672. It has already been remarked, that the green colour of the leaves, young bark, calyx, and carpels, depends on the presence of chlorophylle (¶ 19). This waxy substance is contained in the deep cells or mesophyllum of leaves, and depends on the action of light for its elaboration. When leaves are grown in darkness, they become colourless from the absence of chlorophylle. Light acts by the fixation

of carbon. The different rays of the spectrum appear to vary in their power of developing the green colour. Senebier performed experiments on the subject, by making the light pass through coloured media, and he was led to the conclusion, that while the yellow rays had the greatest effect on the growth of the plant, the blue and chemical rays were those chiefly concerned in the production of the green colour. Hunt seems to agree with Senebier. Other experimenters, however, as Morren, Daubeny, Draper, and Gardner, think the yellow rays are the most active in producing the green colour. The following table shows the result of some of Gardner's experiments. The rays are denominated *active* or *inactive* in relation to their power of producing a green colour, and the figures under each of them show their power in this respect, 1 being the highest value. The sign — indicates that the effect was not satisfactorily tested:—

Ex. Plants.	Hours of sunshine.	Total time.	Active Rays.				Inactive.		
			Red.	Or.	Yel.	Gr.	Bl.	In.	Vi.
1. Turnips	22	109	4	2	1	3	0	0	0
2. Beans	14	95	—	2	1	3	0	—	—
3. Turnips	8	69	4	2	1	3	—	—	—
4. Turnips	23	101	—	—	—	1	0	0	0
5. Turnips	17·5	52	—	2	1	3	4	0	0
6. Turnips	5·5	6	4	2	1	3	0	0	0

673. The ray producing the green colour is found to be that which acts most efficiently in the decomposition of carbonic acid, as shown by the following table:—

Places of spectrum examined.	Production of chlorophylle.	Decomp. of CO_2.	Illuminating power.
Extreme Red	0·000	0·0000	0·0000
Commencement of Orange	——	·5500	——
Centre of Orange	·777	——	——
Centre of Yellow	1·000	1·0000	1·0000
Centre of Green	·583	——	——
Centre of Blue	·100	——	——

674. The green colour becomes lighter or deeper according to the quantity of chlorophylle and the aggregation of the cells. It is usually paler on the lower sides of leaves. The dark shades of green in the Yew, Bay, and Holly, are the effect of an immense crowding together of green cells.

675. As light decreases in autumn, the chlorophylle, in many cases, diminishes, and is probably altered by the loss of a portion of carbon. Thus, Evergreen leaves become of a paler colour, and deciduous leaves assume various hues, commonly called autumnal tints. The leaves of the Poplar, Ash, and Beech, before falling, become yellow; those of some species of Rhus, bright red; those of Cornus sanguinea, dull red; those of the Vine, yellow and purple. Berzelius states, that the leaves become red in plants having red fruits. Robinet and Guibourt maintain that the Vines which produce bluish grapes, have red leaves

in autumn, while such as produce white grapes have yellow leaves. These yellow and red colours by some are said to depend on changes in the state of oxidation of the chlorophylle, and have been traced by others to the production of peculiar waxy substances, one red, called *erythrophylle*, the other yellow, *xanthophylle*. Marquart believes that the action of water on chlorophylle, in different proportions, gives rise to yellow and blue matters. Ellis supposed the change of hues to be due to the prevalence of acid and alkaline matters.

676. Dr. Hope endeavoured to show that there is in plants a colourable principle, *chromogen* (χρῶμα, colour, and γεννάω, I generate,) consisting of two separate principles, one of which forms a red compound with acids, while the other forms a yellow with alkalies, and he attributes the green colour produced by the latter to the mixture of the yellow matter with the blue infusion. The two principles, according to him, may exist together, or separate, in different parts of the same plant. In some very fleshy leaves, as Agave, the central cells are pale, while those of the cuticle are coloured and much thickened. Although leaves are usually of a green colour, still they frequently assume various tints. In certain varieties of Beech and Beet, they become of a uniform red or copper colour. In some cases, only one of the surfaces of the leaf is coloured, as in many species of Begonia, Saxifraga, Cyclamen, and Tradescantia, in which they are green above and red or brown below; while in others there is a variation of colour, giving rise to variegation, as in Aucuba japonica, Carduus marianus, and Calathea zebrina, where there are yellowish spots, or in many Arums, where they are of a red colour. The whitish or brown spots which occur on leaves, are often produced by thickened cells containing peculiar colouring matter, underlying the chlorophylle cells. In such cases, variegation might be traced to an alteration in the epidermal cells, and the same is true of certain bright colours assumed by the surfaces of some leaves. The juices of many plants are colourless when contained in the vessels, but become milky or coloured by exposure to the air. Thus, the sap of Œnanthe crocata becomes yellow, that of Chelidonium orange, that of Madder changes from yellow to red, and that of some Boletuses becomes blue or bluish-green. In some instances, the changes have been prevented by keeping the cut or broken surfaces in nitrogen or hydrogen, or arbonic acid, and thus preventing their exposure to oxygen. It is aid, however, that the change of colour in the Madder does not take lace in pure oxygen.

677. The bark, at first green, becomes often of a brown colour from e thickening of the cell-walls, as well as the deposition of brown atter. Similar changes take place in the woody fibres, giving rise the coloured duramen of many trees, as the Laburnum, Guaiac, bony, &c. Such changes, however, depend on chemical actions going

on in the interior of stems, and are not due to the direct influence of the air. The colour of wood, however, is generally deepened when exposed to the atmosphere.

678. The red, blue, and yellow colours of flowers depend on fluid or semifluid matters contained in superficial cells, which can be detached with the cuticle. This coloured cellular tissue is called by Nourse the *Rete*, and lies immediately below the epidermis. In this respect these colours differ from the green colour in the leaf which is confined to the central cells, and which, as already stated, owes its origin to a granular matter of a peculiar nature. In petals, different cells frequently contain different kinds of colouring matter, thus giving rise to variegation. By the juxtaposition and mechanical mixture of various cells, different tints are produced; and the colours are also modified by the nature of the cuticle through which they are seen. In the interior of petals, the colour is generally more or less yellow, but it is modified when seen through superficial cells. Along with the colouring matter, there is a colourless substance present, the relative quantity of which varies, and hence the colour may be deeper or fainter. In flowers as well as in leaves, the colours appear to depend on the action of light. It has been said, however, that the powerful action of solar light, in some cases, tends to decolorize flowers. Hence, tulips are screened by floriculturists from the direct rays of the sun. The leaves of herbaceous plants also, when exposed to the direct rays of the sun, do not acquire so deep a green as when they are subjected merely to a bright daylight.

679. The colours of flowers have been arranged in two series:— 1st. The *xanthic* (ξανθὸς, yellow) or yellow; and 2d. The cyanic (κύανος, blue) or blue; and it has been shown that plants in general may be referred to one or other of these series, while red is common to both series, and green, as composed of blue and yellow, is intermediate between them. White is considered as depending on absence or extreme dilution of the colouring principles, while brown or black depends on their accumulation or concentration. Even in white flowers there will be seen a slight admixture of a yellowish or bluish tint.

Green.

Cyanic series.		Xanthic series.
	Greenish-blue.	
	Blue.	
	Violet-blue.	
	Violet.	
	Violet-red.	
	Red.	

Cyanic series.	Xanthic series.
Greenish-blue.	Yellowish-green.
Blue.	Yellow.
Violet-blue.	Orange-Yellow.
Violet.	Orange.
Violet-red.	Orange-Red.
Red.	Red.

680. Some starting from greenness, as a state of equilibrium between the two series, pass through the blue and violet to red, by a process of oxidation, while the transition from red to orange and yellow has been traced to deoxidation. As illustrations of the cyanic series may be

ntioned, all, or nearly all, the species of Campanula, Phlox, Epilo-
im, Hyacinth, Geranium, Anagallis; of the xanthic series, Cactus,
oe, Cytisus, Oxalis, Rose, Verbascum, Potentilla, Œnothera, Ranun-
lus, Adonis, Tulip, Dahlia.

681. Plants belonging to either series, vary in colour usually by
ing or falling in the series to which they belong, and not by passing
m one to the other. Thus, a plant belonging to the blue series
s not usually become yellow, nor does one in the yellow series
nge into a pure blue. This remark will not apply in all cases,
hough it is generally true. It cannot be said to hold good in re-
rd to genera, as at present determined; thus, in the genus Gentian,
re are blue and yellow species. It seems, however, to be applicable
individual species; thus, the Dahlia belonging to the yellow series
y pass through all the varieties of that series, but has never
en produced of a blue colour; so also with the Tulip, the Rose, &c.
en in the case of species, however, there are anomalies. Thus, the
le does not apply to such plants as Myosotis versicolor and Dendro-
m sanguinolentum, where there are different yellow and blue colours
the corolla. Notwithstanding, however, all the exceptions, the
neral law already mentioned as to the variation of colour in flowers,
ms to be founded on correct observations.

682. Changes are produced in the colour of flowers, by bruising and
uring the petals. The pure white flowers of Camellia easily become
wn, while those of Calanthe veratrifolia and Bletia Tankervillæ
ume a deep blue. By drying, many flowers become of a brown or
ck colour; this is particularly the case with Orchidaceæ, Melam-
rum, and Orobus niger. It would appear to depend on the com-
ation between the colouring principle and the oxygen of the air,
d may in some cases be traced to the existence of tannin, gallic acid,
d iron. Blue flowers, under the process of desiccation, are often
itened. Ipomœa Learii, in drying, changes from blue to red.

683. Remarkable changes take place in the colour of some flowers
ring the course of the day. The flowers of the common pink Phlox,
ly in the morning, have a lightish blue colour, which alters as the
advances, and becomes bright pink. The Œnothera tetraflora has
ite flowers which change to red. Hibiscus variabilis has its flowers
ite in the morning, pink at noon, and bright red at sunset. The
our of many flowers of Boraginaceæ, before expansion, are red; after
pansion, blue. The bracts of Hakea Victoria are yellowish-white in
centre the first year; the second year, what was white becomes a
h golden yellow; the third year, the yellow becomes rich orange;
fourth year, the colour becomes blood-red; the green portion of
bracts becomes annually darker. It has been stated that soils
e an effect on the colour of flowers. The flower of the common
drangea hortensis may be changed from pink and rose-coloured to

blue, by growing the plant in certain kinds of loam and peat earth. Alum in the soil is said to produce a similar effect.

684. Köhler and Schubler have endeavoured to determine the relative proportions between the different colours met with in flowers. They examined upwards of 4000 species, belonging to twenty-seven natural orders, of which twenty were dicotyledonous, and seven monocotyledonous. The following are some of their conclusions:—

1. White	1193	6. Green	153
2. Yellow	951	7. Orange	50
3. Red	923	8. Brown	18
4. Blue	594	9. Nearly Black	8
5. Violet	307		

685. The proportion of white, cyanic, and xanthic flowers varies in different quarters of the globe, and at different elevations. The following are the proportions of colour in different natural orders, deduced from the examination of about 120 species of each:—

	Red.	Violet.	Blue.	Green	Yel.	Orange.	White.
Nymphæaceæ	11	—	14	—	28	—	46
Rosaceæ	32	1	—	—	52	—	40
Primulaceæ	41	7	6	2	15	10	27
Boraginaceæ	10	9	28	3	13	1	35
Convolvulaceæ	39	10	12	—	7	2	27
Ranunculaceæ	16	4	15	2	42	1	19
Papaveraceæ	38	9	—	—	36	7	7
Campanulaceæ	5	21	58	—	3	1	10

Thus, Nymphæaceæ and Rosaceæ, according to Schubler and Köhler's observations, contain a large number of white flowering species; Primulaceæ and Convolvulaceæ, red; Campanulaceæ, blue; Ranunculaceæ, yellow.

686. In arranging flowers in a garden, it is of importance to place the complementary colours together, in order to produce the best effect. The complementary colour of red, or that which is required to make white light, is green; of orange, blue; of yellow, violet; consequently blue and orange coloured flowers, yellow and violet, may be placed together; while red and rose-coloured flowers harmonize well with their own green leaves. When the colours do not harmonize, the interposition of white or of black often restores harmony.

5.—Odours of Flowers.

687. The peculiar odours of plants depend on various secreted volatile matters, which are often so subtle as to be incapable of detection by ordinary chemical means. Nothing is known of the causes which render one flower odoriferous and another scentless. In some cases the odours of plants remain after being dried, but in general they

ppear. Some leaves, as of the Woodruff, become scented only
r drying; and certain woods, as Teneriffe rosewood, give out their
ur only when heated by friction. Meteorological causes have a
at influence on the odours of living plants. Dew, or gentle rain
h intervals of sunshine, seem to be the circumstances best fitted
eliciting vegetable perfumes. Light has a powerful effect on the
ur as well as the colour of flowers. Plants, when etiolated by being
t in darkness, generally lose their odour. In certain cases, the per-
nes of flowers are developed in the evening. Some of these plants
re called *tristes* by Linnæus, as Hesperis tristis, or night-scented
ck. Many orchidaceous plants are fragrant at night only, as some
tasetums and Cymbidiums. Cestrum nocturnum and the white
wers of Lychnis vespertina are also night-scented. The odours of
ne plants are peculiarly offensive. This is the case with Phallus
pudicus, and with the flowers of many Stapelias.

688. Schubler and Köhler, whose investigations in regard to colour
ve been noticed, have also made observations on the odours of
nts in the same monocotyledonous and dicotyledonous orders. The
lowing tables show some of their results:—

Colour.	No. of species	Odoriferous.	Agreeable.	Disagreeable.
White	1193	187	175	12
Yellow	951	75	61	14
Red	923	85	76	9
Blue	594	31	23	7
Violet	307	23	17	6
Green	153	12	10	2
Orange	50	3	1	2
Brown	18	1	0	1

us, of the plants examined, those having white flowers presented
e larger proportion of odoriferous species. The orange and brown
loured flowers often gave a disagreeable odour. In examining
merous species from various natural orders, they found that out of
0 species of—

Nymphæaceæ	22	were odoriferous.
Rosaceæ	13	——
Primulaceæ	12	——
Boraginaceæ	6	——
Convolvulaceæ	4	——
Ranunculaceæ	4	——
Papaveraceæ	2	——
Campanulaceæ	1	——

6.—DISEASES OF PLANTS.

689. Great obscurity attends this department of botany, and much
mains to be done ere a system of vegetable nosology (νόσος, disease)

can be completed. It is, however, of great importance, wh regard its bearing on the productions of the garden or the field have divided the diseases of plants into *general*, or those affe whole plant, and *local*, or those affecting a part only. arrangement seems to be founded on their apparent cause this way they have been divided by Lankester into four gr Diseases produced by changes in the external conditions of by redundancy or deficiency of the ingredients of the soil, heat, air, and moisture. 2. Diseases produced by poisonou as by injurious gases, or miasmata in the atmosphere, or p matter in the soil. 3. Diseases arising from the growth of plants, as Fungi, Dodder, &c. 4. Diseases arising from m injuries, as wounds and attacks of insects.

690. Plants are often rendered liable to the attacks of d the state of their growth. Thus, cultivated plants, especiall become succulent by the increase of cellular tissue, appear to predisposed to certain diseases than others. Concerning the causes of disease very little is known. Absence of light cause *ing*, which may be looked upon as a diseased state of the tissu cess of light may cause disease in plants whose natural habitat places. Excess of heat is sometimes the occasion of a b diseased state of some of the organs of the flowers, and prejudicially on the leaves, stem, and flowers. By excess of a dropsical state of the tissue is induced.

691. Concerning the influence of atmospheric changes o very little has been determined. Many extensive epidemics depend on this cause. Thus, the late potato disease must b apparently, to some unknown miasma conveyed by the operating over large tracts of country; the disease probably some plants more than others, according to their state of predi and in its progress leading to disorganization of the textures, in the contents of the cells and vessels, and the production &c. In the early stage of the disease, as witnessed in 1845, observed that a brown granular matter was deposited in th of the cells, beginning with those near the surface. For so the cell-walls and starch-grains remained uninjured, but w mately attacked, the former losing their transparency, and becoming agglomerated in masses. Subsequently to this, organisms of various kinds made their appearance, cavities wer and rapid decay took place. Among the vegetable parasites, tected species of Fusisporium, Oidium, Botrytis, Capillaria, Berkeley supports the Fungus theory of Potato disease, while So that the development of parasites is a secondary step in th process. The prevalence of hot or cold weather, the amoun and moisture, changes in the atmosphere, and electrical con

he air and earth, are in all probability connected with epidemic iseases. Some, with Liebig, attribute the late potato disease to supressed evaporation and transpiration, depending on the hygrometric tate of the atmosphere. The vessels and cells are said to become harged with fluids, stagnation of the circulation takes place, and thus isease and death are induced.* The general conclusions to be drawn rom the various researches that have been instituted and opinions hich have been advanced respecting the cause and progress of this pidemic may be thus stated. Coincident with, if not consequent on ertain meteorological and epidemic influences, alterations are accomlished in the cellulose and contents of the cells. Decay follows on hose changes. In the decayed and decaying matter, parasitic Fungi nd a nidus for growth and progress equally with the disease of which hey are primarily a consequence, and to the extension of which they n their turn contribute.

692. *Gangrene* in plants is caused by alterations in the contents of he cells, leading to death of a part. In succulent plants, as Cactuses, his disease is apt to occur. It is capable of extension by contact of he diseased cells. Sometimes excision of the diseased part checks the rogress of the gangrene. *Canker*, which attacks Apple and Pear trees, s a kind of gangrene. Some of the most important diseases of corn and ther agricultural crops, are owing to the production of Fungi. These ave been divided into 1. Those attacking the grain, as Uredo fœtida, r pepper-brand. 2. Those attacking the flower, as Uredo segetum, r smut. 3. Those attacking the leaves and chaff, as Uredo Rubigo, r rust. 4. Those attacking the straw, as Puccinia graminis, or corn ildew.

693. *Smut-balls*, *pepper-brand*, or *blight*, is a powdery matter, occuying the interior of the grain of wheat, &c. When examined under he microscope, it consists of minute balls, four millions of which may xist in a single grain, and each of these contains numerous excessively inute sporules. It is caused by the attack of Uredo Caries, or fœtida. n this disease the seed retains its form and appearance, and the arasitic fungus has a peculiarly fetid odour, hence called *stinking* ust.

694. *Smut* or *dust-brand* is a sooty powder, having no odour, found n Oats and Barley, and produced by Uredo segetum. The disease hows itself conspicuously before the ripening of the crop. Bauer says hat in $\frac{1}{160000}$ part of a square inch he counted 49 spores of the redo.

695. *Rust* is an orange powder, exuding from the inner chaff scales, nd forming yellow or brown spots and blotches in various parts of orn plants. It owes its presence to the attack of Uredo Rubigo. It

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* See remarks on this subject by Klotzsch, translated by Gregory, in the Appendix to Liebig's rk on the Motion of the Juices. London, 1848.

is sometimes called *red gum*, *red robin*, *red rust*, and *red rag*. Some consider Mildew (Uredo linearis) as another state of the same disease.

696. Those Fungi which are developed in the interior of plants, and appear afterwards on the surface, are called *entophytic* (*ἐντὸς*, within, and *φυτὸν*, a plant). Their minute sporules are either directly applied to the plants entering by their stomata, or they are taken up from the soil. Many other Fungi grow parasitically on plants, and either give rise to disease, or modify it in a peculiar way. Among them may be mentioned species of Botrytis, Fusisporium, Depazia, Sclerotium, Fusarium, and Erysiphe. Fusisporium solani is considered by Martins as the cause of a certain disease in the Potato. In the recent potato disease, the Botrytis infestans, a species of Fusarium, and other Fungi, committed great ravages, spreading their mycelium or spawn through the cells of the leaves and the tuber, and thus accelerating their destruction. Berkeley, Morren, and Townley, consider the Botrytis as the cause of the disease. Various species of Botrytis also attack the Tomato, Beet, Turnip, and Carrot. A species of Depazia sometimes causes disease in the knots of Wheat. A diseased state of Rye and other grasses, called *ergot*, owes its production to the presence of a species of Cordyceps. By the action of the fungus, the ovary becomes diseased and altered in its appearance, so as to be dark-coloured, and project from the chaff in the form of a spur. Hence the name *spurred rye*. The nutritious part of the grain is destroyed, and it acquires certain qualities of an injurious nature. Spontaneous gangrene is the consequence of living for some time on diseased rye. Ergot has been seen in Lolium perenne and arvense, Festuca pratensis, Phleum pratense, Dactylis glomerata, Anthoxanthum odoratum, Phalaris arundinacea, &c.

697. Fruits when over-ripe are liable to attacks of Fungi, which cause rapid decay; Wood also, especially Alburnum or sap-wood, is injured by the production of Fungi. Dry rot is the result of the attack of Merulius lacrymans, which in the progress of growth destroys its texture, and makes it crumble to pieces. Some kinds of wood are much more liable to decay than others.

698. The diseases caused by attacks of Fungi may be propagated by direct contact, or by the diffusion of the minute spores through the atmosphere. When we reflect on the smallness of the spores, the millions produced by a single plant, and the facility with which they are wafted by the wind in the form of the most impalpable powder, we can easily understand that they may be universally diffused and to be developed in any place where a nidus is afforded. Per- me of the diseases affecting man and animals may be traced a source. Quekett found that he could propagate the mixing the sporules with water, and applying this to the

699. In order to prevent these diseases, it has been proposed to steep the grains in various solutions previously to being sown. For this purpose, alkaline matters and sulphate of copper have been used. In all cases, the seed should be thoroughly cleansed. Smut and pepper-brand have been averted by these means. In the case of the latter, diseased grains are easily removed by being allowed to float in water, and the grains that remain are washed with a solution of lime, common potash, or substances containing ammonia, which form a soapy matter with the oil in the fungus. A weak solution of sulphate of copper acts by destroying the fungus. To preserve wood from dry rot, the processes of kyanizing and burnetizing have been adopted: the former consists in making a solution of corrosive sublimate enter into the cells and vessels; the latter, in impregnating the wood with a solution of chloride of zinc. Creosote has also been used to preserve wood. Boucherie proposed that a solution of pyrolignite of iron should be introduced into trees before being felled, by making perforations at the base of the trunk, and allowing the absorbing power of the cells and vessels to operate. This plan does not appear to have been successful, although reported favourably to the French Academy, and also recommended by Mr. Hyett.

700. Other diseases in plants owe their origin to *insects*. *Earcockles*, *purples*, or *pepper-corn*, is a disease affecting especially the grains of wheat. The infected grains become first of a dark green, and ultimately of a black colour. They become rounded like a small pepper-corn, but with one or more deep furrows on their surface. The glumes spread open, and the awns become twisted. The blighted grains are full of a fine white cottony matter, which, when moistened and put under the microscope, is seen to consist of a multitude of minute individuals of the Vibrio triciti, or eel of the wheat. The animalcules deposit their eggs in the ovary, and their young are hatched in eight or ten days. Henslow calculates that 50,000 of the young might be packed in a moderately sized grain of wheat. The Vibrio retains its vitality long. It will remain in a dry state for six or seven years, and when moistened with water will revive. The wheat-fly, or Cecidomyia tritici, is another destructive insect. It deposits its eggs by means of a very long retractile ovipositor, and is seen abundantly in warm evenings. The Cecidomyia destructor, or Hessian fly, also causes injury, and is said to be very destructive to wheat in America. These insects are destroyed in numbers by the Ichneumons, which deposit their ova in their bodies. The Apple-tree mussel, or dry-scale, Aspidotus conchiformis, attacks the bark of Apples, Pears, Plums, Apricots, and Peaches. Many of the Coccus tribe are highly injurious to plants. One of this tribe, in 1843, destroyed the whole orange trees in the island of Fayal, one of the Azores. Many insects cause the rolling up of leaves. Tortricida viridana acts thus on the leaves of the Oak, and

various species of Lozotaenia do so with other trees. Adelges abietis is the aphis which causes the leaves of the Spruce-fir to be united together, so as to have the appearance of a cone.

701. Many insects, called miners, make their way into the interior of leaves, and hollow out tortuous galleries, sometimes causing an alteration in the colour of the leaves. Galls are caused by the attacks of species of Cynips, which are provided with ovipositors, by means of which they pierce the bark or leaves with the view of having a nidus for their ova. These galls are very common on the Oak, and are called oak-apples. Sometimes they have one cavity, at other times they are divided into numerous chambers, each containing a grub, pupa, or perfect fly, according to the season. Galls are produced on the twigs, catkins, and leaves of the Oak. The artichoke gall of the Oak depends on an irregular development of a bud, caused by the attack of insects, and consists of a number of leafy imbricated scales resembling a young cone. On examining the galls of commerce, the produce of the Quercus infectoria, some are of a blue colour, containing the larva of the insect; others are pale, and are marked with a perforation by which the insect has escaped. Extensive ravages are committed in Elms and other trees by the attacks of Scolyti. The presence of much moisture, such as the rapid flow of sap, destroys them. Mr. Robert found that the flow might be promoted by taking off the suberous layer of the bark, and he proposes this as a method of getting rid of the insects. Some galls are formed in the substance of leaves, and burst through the cuticle in the form of ovate bodies, with crenate borders and opercula, which are perforated in the centre. These galls resemble parasitic fungi. *Oak-spangles* are galls of this nature. They are attached by a central point to the outer surface of the leaf, the inner side being smooth—the outer red, hairy, and fringed. Each contains a single insect, which retains its habitation till March, long after the leaves have fallen to the ground.

702. It is impossible in this place to enumerate all the insects which attack plants. Almost every species has certain insects peculiar to it, which feed on its leaves, juices, &c., and often cause great injury. Those which are common to hot-houses and green-houses, have called for the special attention of horticulturists, and various means have been suggested for their removal or prevention. Among them may be enumerated, vapour of tobacco and ammoniacal liquor of gas-works, to kill aphides; vapour of sulphur, for the red spider; vapour of turpentine, for the wasp; vapour of crushed laurel leaves, for the white bug; coal tar, for the wire-worm, &c.*

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* For further remarks on the Diseases of Plants, see Henslow's paper in the Journal of the Royal Agricultural Society of England.

PART II.

SYSTEMATIC BOTANY, TAXONOMY, OR THE CLASSIFICATION OF PLANTS.

CHAPTER I.

SYSTEMS OF CLASSIFICATION.

703. This department of Botany may be considered as a combination of all the observations made on the structure and physiology of plants, with the view of forming a scientific arrangement. It can only, therefore, be prosecuted successfully after the student has acquired a complete knowledge of Organography. In every branch of science, arrangement is necessary in order that the facts may be rendered available, and this is more especially the case when a knowledge of species is to be acquired. When it is considered that there are upwards of 120,000 known species of plants, it is obvious that there must be a definite nomenclature and classification, were it only to facilitate reference and communication. Taxonomy has sometimes been pursued with no higher aim than that of knowing the names of plants. When prosecuted in such a spirit, it does not lead to an enlarged and philosophical view of the vegetable kingdom. In all truly scientific systems, regard is paid, not merely to the determination of the names of the species, but to their relations and affinities, so as to give some conception of the order which has been followed in the plan of creation.

704. In Classifactory Sciences, the arrangements are founded upon an *idea of likeness*—an idea, however, which is applied in a more exact and rigorous manner than in its common and popular employment. The resemblances of the objects must rest, not on vague generalities, but upon an accurate scientific basis. In order that an arrangement may be constructed on philosophical principles, and that it may be rendered useful for the purpose of science, the following steps are required:—1. A Technical (τεχνικὸς, artificial or conventional) language,

rigorously defined, or what is termed Glossology (γλῶσσα, a tongue or language, and λόγος, a discourse), and Termonology (τέρμων, -ονος, a termination). The meaning of the terms in this descriptive language must not depend on fancied resemblances, but must have a precise definition, and be constant. In acquiring a knowledge of the conventional terms, or of the vocabulary of the science, the student at the same time fixes in his mind the perceptions and notions which these terms convey, and thus, in reality, becomes acquainted with important elementary facts. 2. A Plan of the system, or the principles on which the divisions and subdivisions of the system are made, Diataxis (διάταξις, orderly arrangement), or what is properly called Taxonomy (τάξις, order, and νόμος, law). There have been two great plans proposed in Botany, one denominated *artificial*, the other *natural*. The first is founded on characters taken from certain parts of plants only, without reference to others; while the second takes into account all the parts of plants, and involves the idea of *affinity* in essential organs. 3. There must be also the means of detecting the position of a plant in a system by short diagnostic marks. In doing so, a few essential characters are selected in accordance with natural affinities. The division into genera is a most valuable help in determining plants. Linnæus did great service to science by his generic divisions, and by adopting a *binominal* (*bis*, twice, and *nomen*, a name) system of nomenclature, in which the genus and species are included in the name of the plant.

705. **Species.**—No classification can be made unless the meaning of the term *species* is defined. By species, then, are meant so many individuals as are presumed to have been formed at the creation of the world, and to have been perpetuated ever since. A species embraces individuals which resemble each other more closely than they do any other plant, so that they are considered as originating from a common parent; and their seeds produce similar individuals. There may be differences in size, colour, and other unimportant respects; and thus *varieties* may exist, exhibiting minor differences, which are not, however, incompatible with a common origin. Varieties owe their origin to soil, exposure, and other causes, and have a constant tendency to return to their original type. They are rarely propagated by seed, but can be perpetuated by cuttings and grafts. By cultivation, permanent varieties or *races* have been produced, the seeds of which give rise to individuals varying much from the original specific type. Such races are kept up entirely by the art of the gardener, and may be illustrated in the case of the Cereal grains, and of culinary vegetables, such as Cabbages, Cauliflower, Brocoli, Turnips, Radishes, Peas. It is only after a series of years that these permanent varieties have been established, and there is still a tendency in their seeds, when sown in poor soil and neglected, to produce the original wild form. Permanent varieties in the animal kingdom may be illustrated by the

different races of mankind. By scattering the pollen of one plant on the pistil of an allied species, seeds are formed, which, when sown, produce intermediate forms or hybrids (¶ 516). Hybrids, however, are rarely perpetuated by seed.

706. Many species vary in a remarkable manner, without any external influences to account for it. Thus, a plant of Fuchsia has produced, in successive years, flowers differing so much in form and shape, that, if they had not been known to be produced by the same plant, they would have been considered as belonging to distinct species. Such is also the case with Calceolarias, some species of Amaryllis, and many Orchids. Hence there is sometimes considerable difficulty in determining what are true species, and what are only varieties, more especially when these varieties are permanent and reproduce themselves. To this must in part be attributed the disputes which have arisen among botanists as to the species of many British genera, such as Roses, Rubi, Salices, and Hieracia. The following table shows the number of British species in some of the British genera, as given by different authors, and exhibits the uncertainty which still exists as to the limits of species :—

	Salix.	Hieracium.	Mentha.	Rosa.	Rubus.	Saxifraga.
Hudson (1798)	16	8	10	5	5	9
Smith (1824-28)	64	18	13	22	14	25
Lindley (1835)	29	19	9	17	21	24
Hooker (1842)	70	13	13	19	14	16
Babington (1843)	57	19	8	19	24	20
Watson (1844)	38	17	8	7	34	16
Arnott (1855)	38	27	9	19	25	16
Babington (1856)	32	33	9	19	41	20
Bentham (1858)	15	7	8	5	5	13

707. It is only after a careful study of such forms during a series of years, that any conclusion can be drawn in regard to them. It is important to record all the varieties which occur, but great care is necessary not to raise to the rank of species what are mere accidental abberrant forms. Some have of late years advocated the doctrine of the transmutation of species or the conversion of one species into another. It has been said, that Oats may be changed into Rye, by being constantly cut down for a series of years before flowering. Such statements are not founded on correct data, and have led to very erroneous views and doctrines, which have been recently promulgated with much apparent plausibility. All that has been observed in the vegetable kingdom leads to the conclusion, that there are distinct species which continue to be perpetuated by seed, and that, although these may vary within certain limits, there is always a typical form to which the varieties have a tendency to revert. By grafting and other horticultural operations, changes of a marked kind may be produced in fruits; but the seeds of such fruit, when sown, give rise to individuals resembling

the original stock—they perpetuate the *typical* form, not the artificially-produced variety.

708. **Genera.**—Certain species are more nearly allied than others, and are conveniently grouped together so as to form a distinct *kind* or *genus*. A genus, then, is an assemblage of nearly related species, agreeing with one another in general structure and appearance more closely than they accord with any other species. Thus, the various species of Roses compose one genus, which is distinguished by marked characters. Occasionally a *subgenus* is formed by grouping certain species, which agree more nearly with each other in some important particulars than the other species of the genus. The characters of the genera are taken exclusively from the parts of fructification, while all parts of the plant furnish specific characters. In the name of a plant, the genus is given as well as that of the species. The latter was called by Linnæus the *trivial* name. Thus, a particular species of Rose is called *Rosa spinosissima;* the first being the genus, and the second the specific or trivial name. As regards the definition of genera and species, and nomenclature in general, no one has conferred so much benefit on science as the great Linnæus. This may be considered as among his highest titles to fame.

709. **Orders.**—Several genera agreeing in more general characters, although differing in their special conformation, are grouped together so as to form an *order* or *family*. As genera include allied species, so orders embrace allied genera. Subdivisions are also made to facilitate reference, so that *suborders* and *tribes* are formed, consisting of certain genera, more nearly related in particular characters than others. Thus, the order Rosaceæ, or the Rose family, includes the genera Rosa, Rubus, Potentilla, Fragaria, Prunus, &c., which all agree in certain general characters; and the order is divided into various suborders, such as the true Roses, the Amygdaleæ, comprehending the Plum, Almond, Peach, &c.; the Potentilleæ, embracing the Cinquefoil, Strawberry, Raspberry, &c. (¶ 854).

710. **Classes.**—Orders having some general characters in common are united together in *classes*, and *subclasses* are formed in the same way as *suborders*. This is the general plan upon which botanical classification proceeds. With the exception of the individual species, all the divisions are more or less arbitrary. In making them, however, the object of the enlightened botanist is to follow what he considers to be the natural affinities, and thus to trace, as far as possible, the order which pervades the vegetable creation.

711. **Essential Characters.**—Each of the divisions of a system is accurately defined, the characters being as short as is consistent with precise diagnosis. Such characters are called *essential*, and they embrace only those points by which the group is distinguished from the others in the same section. The complete description of an individual

, from the root to the flower and fruit, is called the *natural* ter, and embraces many particulars which are not requisite for rpose of diagnosis. The essential characters of genera, when in are put in the nominative case, while those of species are in the e.

. **Nomenclature.**—The names of genera are variously derived, he structure or qualities of the group, from the name of some it botanist, &c.; while specific names have reference also to the y where the plant is found, the locality in which it grows, the f the leaves, root, stem, or the colour of the flowers, &c. When es is named in honour of its discoverer or describer, his name in the genitive, as *Carex Vahlii*, or the Carex detected by Vahl; it is merely in compliment to a botanist his name is added in ective form, as *Jungermannia Doniana*, or a Jungermannia named our of Don, as a botanist. Sometimes two nouns are united in fic name, as *Dictamnus Fraxinella.* In such cases, the specific is often an old generic one, has a capital letter prefixed, and ot necessarily agree in gender with the name of the genus. The of the orders in what is called the natural system, are derived ne of the typical genera included under them.

. **Abbreviations and Symbols.**—It is of great importance that descriptions should be given of species, for without them it is ible to form the groups accurately. The difficulties of the mist are often greatly increased by imperfect and careless tions. Valuable directions are given in Lindley's Introduction any, as to the proper method of describing plants. There are abbreviations in constant use among botanists, which it may importance to notice here. The authorities for genera and are given by adding the abbreviated name of the botanist who ed them. Thus *Veronica L.*, is the genus Veronica as defined næus; *Veronica arvensis L.*, is a certain species of Veronica, de- by the same author; *Oxytropis DC.*, is the genus as defined by ndolle. It is usual in descriptive works to give a list of the s, and the symbols for their names. The abbreviation v. s. sp., *vidi siccam spontaneam*, or that the author has seen a dried wild en of the plant; v. s. c., means *vidi siccam cultam*, or that he n a dried cultivated specimen; v. v. s., means *vidi vivam spon-*, or that he has seen a living wild specimen; while v. v. c., *vidi vivam cultam*, or that the author has seen a living cultivated en. The asterisk prefixed to a name (*L.), indicates that there od description at the reference given to the work; while the (†L.), implies some doubt or uncertainty. The point of admira- DC.), marks that an authentic specimen has been seen, from hor named; and the point of interrogation (?) indicates doubts he correctness of genus, species, &c., according as it is placed to the work in which the description may be found. If it l ceived different names, the synonymes must be carefully detail ought to be arranged in chronological order.

714. **Systems.**—Various attempts have been made at differen to classify plants. One of the earliest methodical arrangeme that of Cæsalpinus, in 1583. It was entirely artificial, and th thing may be affirmed of those of Gesner, Morison, Rivinus, and nefort. The system propounded by Tournefort was for a lon adopted by the French school, but was ultimately displaced l of Linnæus, who must be looked upon as the great promulgato artificial method. In 1682, Ray published a system which l foundation of the natural method of classification. It wa neglected, and did not receive the attention it deserved, until entered the field, and developed his views. Since that tin natural method has been advanced by the labours of De C Brown, Endlicher, Lindley, and many others.

715. **Linnæan System.**—Although the Linnæan system is conformity with natural affinities, and does not tend to comp sive views of structure, still it is useful to the student as an Linnæus himself did not consider it as occupying a higher p and he stated distinctly that a natural method was the great o scientific inquiry. When not elevated to a rank which its never meant it to occupy, this system may, with all its imperf be employed as a useful artificial key, and as such may be co with the natural system. In many works of the present day Babington's Manual of British Botany, the Linnæan system as an index to the genera. In the Linnæan or sexual system, t three classes are founded on the number, position, relative lengt

716. TABULAR VIEW OF THE CLASSES OF THE LINNÆAN SYSTEM.

A. Flowers present (Phanerogamia).			
I. Stamens and Pistil in every flower.			
1. Stamens Free.			
a. Stamens of equal length, or not differing in certain proportions;			ἀνὴρ, male or stamen.
in number 1	Class I.	Monandria	μόνος, one.
— 2	II.	Diandria	δὶς, two.
— 3	III.	Triandria	τρεῖς, three.
— 4	IV.	Tetrandria	τετρὰς, four.
— 5	V.	Pentandria	πέντε, five.
— 6	VI.	Hexandria	ἕξ, six.
— 7	VII.	Heptandria	ἑπτὰ, seven.
— 8	VIII.	Octandria	ὀκτὼ, eight.
— 9	IX.	Enneandria	ἐννέα, nine.
— 10	X.	Decandria	δέκα, ten.
—12-19	XI.	Dodecandria	δώδεκα, twelve.
— 20 or more Inserted on Calyx	XII.	Icosandria	εἴκοσι, twenty
— 20 or more — on Receptacle	XIII.	Polyandria	πολὺς, many.
b. Stamens of different lengths;			
two long and two short	XIV.	Didynamia	δύναμις, power.
four long and two short	XV.	Tetradynamia	
2. Stamens united;			
by Filaments in one bundle	XVI.	Monadelphia	ἀδελφὸς, brother.
—— in two bundles	XVII.	Diadelphia	
—— in more than two bundles.	XVIII.	Polyadelphia	
by Anthers (Compound flowers)	XIX.	Syngenesia	σὺν, together. γένεσις, origin.
with Pistil on a Column	XX.	Gynandria	γυνὴ, female.
II. Stamens and Pistil in different flowers; on the same Plant	XXI.	Monœcia	οἶκος, house.
on different Plants	XXII.	Diœcia	
III. Stamens and Pistil in the same or in different flowers on the same or on different plants	XXIII.	Polygamia	γάμος, marriage.
B. Flowers Absent	XXIV.	Cryptogamia	κρυπτὸς, concealed.

717. TABULAR VIEW OF THE ORDERS OF THE LINNÆAN SYSTEM.

γυνὴ, female or pistil.

Class I.	Monogynia	1	Free Style	μόνος, one.
II.	Digynia	2	Free Styles	δὶς, two.
III.	Trigynia	3	—	τρεῖς, three.
IV.	Tetragynia	4	—	τετρὰς, four.
V.	Pentagynia	5	—	πέντε, five.
VI.	Hexagynia	6	—	ἕξ, six.
VII.	Heptagynia	7	—	ἑπτὰ, seven.
VIII.	Octogynia	8	—	ὀκτὼ, eight.
IX.	Enneagynia	9	—	ἐννέα, nine.
X.	Decagynia	10	—	δέκα, ten.
XI.	Dodecagynia	12-19	—	δώδεκα, twelve.
XII.	Polygynia	20 and upwards		πολὺς, many.
XIII.				

XIV.	Gymnospermia	Fruit formed by four Achænia	γυμνὸς, naked.
	Angiospermia	Fruit, a two-celled Capsule with many seeds	ἀγγεῖον, a vessel. σπέρμα, a seed.
XV.	Siliculosa	Fruit, a Silicula.	
	Siliquosa	Fruit, a Siliqua.	
XVI. XVII. XVIII.	Triandria, Decandria, &c. (number of Stamens), as in the Classes.		
XIX.	Polygamia Æqualis	Florets all hermaphrodite.	
	——— Superflua,	Florets of the disk hermaphrodite, those of the ray pistilliferous and fertile.	
	——— Frustranea	Florets of the disk hermaphrodite, those of the ray neuter.	
	——— Necessaria	Florets of the disk staminiferous, those of the ray pistilliferous.	
	——— Segregata	Each floret having a separate involucre.	
	Monogamia	Anthers united, flowers not compound.	
XX. XXI. XXII.	Monandria, Diandria, &c. (number of Stamens), as in the Classes.		
XXIII.	Monœcia	Hermaphrodite, staminiferous, and pistilliferous flowers on the same plant.	
	Diœcia	on two plants.	
	Triœcia	on three plants.	
XXIV.	Filices	Ferns.	
	Musci	Mosses.	
	Hepaticæ	Liverworts.	
	Lichenes	Lichens.	
	Algæ	Sea-weeds.	
	Fungi	Mushrooms.	

718. Even as an artificial method, this system has many imperfections. If plants are not in full flower, with all the stamens and styles perfect, it is impossible to determine their class and order. In many instances, the different flowers on the same plant vary as regards the number of the stamens. Again, if carried out rigidly, it would separate in many instances the species of the same genus; but as Linnæus did not wish to break up his genera, which were founded on natural affinities, he adopted an artifice by which he kept all the species of a genus together. Thus, if in a genus nearly all the species had both stamens and pistils in every flower, while one or two were monœcious or diœcious, he put the name of the latter in italics, in the classes and orders to which they belonged according to his method, and referred the student to the proper genus for the description,

719. **Natural System.**—It has been already stated, that a natural system endeavours to bring together plants which are allied in all essential points of structure. It purposes to ascertain the system of nature, and the affinities of plants; and, in doing so, it takes into account all their organs. Every natural method, however, is, to a certain extent, artificial, and is likely to be so. It is impossible to show the affinities of plants in a *lineal* series; many orders pass insen-

others, so that their limits cannot be accurately defined; and t system can be constituted until all the plants of the globe rn. Moreover, many artificial means are avowedly used in ıl systems to aid the student.

The early natural systems were very imperfect, being founded ratively vague views of structure and affinity. Such were ns of Magnolius and Adanson. The sketch of a natural sys- innæus was very incomplete, and even that of the celebrated imperfect. It was not until the knowledge of structural ıd advanced, that the affinities of plants were ascertained, and ive importance of the different characters discovered. The ystems of the present day recognize a certain subordination ters, founded on the fact that some organs are of more impor- the life of plants than others. The relative values of these s are determined by the study of organization, and are not arbitrary rules. The following table will illustrate this ıtion of character:—

SUBORDINATION IN VALUE OF THE ORGANS OF THE SAME CLASS.

ues.	Elementary.	Nutritive.	Reproductive.
	Cellular Tissue.		
	Vascular Tissue......	Embryo.	—
	a. Spiral Vessels..	*a.* Cotyledon.	—
	b. Porous Vessels.	*b.* Radicle.	—
	c. Scalariform	*c.* Plumule.	—
	Vessels.......	Spore.	—
	Stomata...............	Prothallus.........	
	——	Root, Stem, Leaf, Frond, Thallus.	1. Stamens and Pistil. 2. Antheridia and Archegonia. 3. Fruit. Pericarp. Theca.
	——	——	Perianth. *a.* Corolla. *b.* Calyx.
	——	——	Inflorescence. Torus, Nectary. Bract, Involucre.

Thus, cellular tissue occupies the highest place, as being most ly diffused, and capable of carrying on all the functions; next scular tissue. By the consideration of these, the two great of cellular and vascular plants are determined. There is n the nutritive and reproductive systems of the same value as ssue. The embryo and its parts are reckoned as occupying st place in the nutritive system, and as corresponding in value vascular among the elementary tissues. In the same way values are determined. In examining organs, it is essential

XIV. [illegible]

XV. [illegible]

XVI.
XVII.
XVIII. [illegible]

XIX. [illegible]

[illegible]

I.	Class	Dicotyledones.
	Subclass	Calycifloræ.
II.	Order	Leguminosæ.
	Suborder	Papilionaceæ.
	Tribe	Loteæ.
	Subtribe	Genisteæ.
III.	Genus	Anthyllis.
	Subgenus or Section	Vulneraria.
IV.	Species	Vulneraria.
	Variety	Dillenii.
	Race	Floribus coccineis.
	Variation	Foliis hirsutissimis.

726. The most important natural systems are those of Jussieu, De Candolle, Endlicher, and Lindley. The larger divisions of each of them are given in a tabular form.

727. CLASSES OF JUSSIEU'S SYSTEM.

Acotyledones					Class I.
Monocotyledones			Mono-hypogynæ,	(Stamens hypogynous)	II.
			Mono-perigynæ	(—— perigynous)	III.
			Mono-epigynæ.	(—— epigynous)	IV.
Dicotyledones.	Monoclines, Flowers hermaphrodite.				
		Apetalæ (No Petals.)	Epistamineæ	(Stamens epigynous)	V.
			Peristamineæ	(—— perigynous)	VI.
			Hypostamineæ	(—— hypogynous)	VII.
		Monopetalæ, (Petals united.)	Hypocorollæ	(Corolla hypogynous)	VIII.
			Pericorollæ	(—— perigynous)	IX.
			Epicorollæ (Corolla epigynous)	Synantheræ (anthers united)	X.
				Corisantheræ (anthers free)	XI.
		Polypetalæ (Petals distinct)	Epipetalæ	(Petals epigynous)	XII.
			Hypopetalæ	(—— hypogynous)	XIII.
			Peripetalæ	(—— perigynous)	XIV.
	Diclines		Flowers unisexual, or without a perianth		XV.

Under these Classes Jussieu included 100 Natural Orders, or Groups of Genera.

728. CLASSES OF THE NATURAL SYSTEM OF DE CANDOLLE.

A. VASCULARES OR COTYLEDONEÆ.

Class I. Dicotyledones or Exogenæ.

Dichlamydeæ, having calyx and corolla.	Subclass 1.	Thalamifloræ	Petals distinct, stamens hypogynous.
	—— 2.	Calycifloræ	Petals distinct or united, stamens perigynous.
	—— 3.	Corollifloræ	Petals united, hypogynous, bearing the stamens.
Having a single perianth.	—— 4.	Monochlamydeæ	A calyx only, or none.

Class II. Monocotyledones or Endogenæ.

Subclass 1.	Mon-Phanerogamæ	Having floral envelopes.
—— 2.	Mon-Cryptogamæ	Having no floral envelopes.

B. CELLULARES OR ACOTYLEDONEÆ.

Class III. Acotyledones.

Subclass 1. Foliosæ	Having leaves.
——— 2. Aphyllæ	Leafless.

729. By some recent authors, this system has been modified, so as to include, under Corollifloræ, all Dicotyledons with united petals, whether hypogynous or not, and to exclude from Class II. all plants without flowers. It is then presented in the following form:—

MODIFICATION OF DECANDOLLE'S SYSTEM.

Class I. Dicotyledones or Exogenæ.

Dichlamydeæ, having calyx and corolla.	Subclass 1. Thalamifloræ,	Petals distinct, stamens hypogynous
	——— 2. Calycifloræ,	Petals distinct, stamens perigynous
	——— 3. Corollifloræ,	Petals united, bearing the stamens
Having a single perianth	——— 4. Monochlamydeæ,	A calyx only, or none.

Class II. Monocotyledones or Endogenæ.

Subclass 1. Petaloideæ or Floridæ,	Floral envelopes verticillate.
——— 2. Glumaceæ,	Floral envelopes imbricated.

Class III. Acotyledones or Acrogenæ.

Subclass 1. Ætheogamæ,	Having vascular tissue.
——— 2. Amphigamæ or Cellulares,	Entirely cellular.

730. SYSTEM OF ENDLICHER.

REGION I.—THALLOPHYTA (θαλλὸς, frond, φυτὸν, a plant). No opposition of stem and root. No spiral vessels, and no sexual organs. Propagated by spores.

SECTION I. PROTOPHYTA (πρῶτος, first or originating). Developed without soil; deriving nourishment all around; fructification indefinite.

SECTION II. HYSTEROPHYTA (ὕστερος, posterior or derivative). Developed on decaying organisms; nourished internally from a matrix; all the organs appearing at once, and perishing in a definite manner.

REGION II.—CORMOPHYTA (κορμὸς, a stalk or trunk). Opposition of stem and root. Spiral vessels and sexual organs distinct in the more perfect.

SECTION III. ACROBRYA (ἄκρα, summit, and βρύω, to germinate). Stem increasing by the apex, the lower part being unchanged, and only conveying fluids.

Cohort 1. Anophyta (ἄνω, above). No spiral vessels. Both sexes present. Spores free within spore-cases.

Cohort 2. Protophyta. Bundles of vessels more or less perfect. No male organs. Spores free within one- or many-celled spore-cases.

Cohort 3. Hysterophyta. Both sexes perfect. Seeds without an embryo, consisting of many spores. Parasitic.

SECTION IV. AMPHIBRYA (ἀμφί, around). Stem increasing at the circumference. Vegetation peripherical.

Section v. ACRAMPHIBRYA (ἄκρα, ἀμφὶ, and βρύω). Stem increasing both by apex and circumference. Vegetation peripherico-terminal.

Cohort 1. Gymnospermæ (γυμνὸς, naked, and σπέρμα, seed). Ovules naked, receiving the fecundating matter directly at the micropyle.

Cohort 2. Apetalæ (ἀ, privative or without, and πέταλον, a petal). Perigone either wanting or rudimentary or simple, calycine or coloured, free or adherent to the ovary.

Cohort 3. Gamopetalæ (γάμος, union). Perigone double; outer calycine, inner corolline; gamopetalous, rarely wanting by abortion.

Cohort 4. Dialypetalæ (διαλύω, I separate). Perigone double; outer calycine, parts distinct or united, free or attached to the ovary; inner corolline, parts distinct or very rarely cohering by means of the base of the stamens; insertion hypogynous, perigynous, or epigynous; sometimes abortive.

ler these sections, Endlicher enumerates 279 natural orders, which grouped under 61 classes.

781. DIVISION OF THE VEGETABLE KINGDOM BY LINDLEY. 1839.

	Cyclogens.	Class I.	Exogens (proper).
;ens…………	(Wood in circles),	II.	Gymnogens (naked seeds).
	Wood in wedges,	III.	Homogens.
	Spermogens,	IV.	Dictyogens (leaves reticulated).
gens ………	(Bearing seeds),	V.	Endogens (proper).
	Bearing spores,	VI.	Sporogens or Rhizanths.
	Distinct Stem,	VII.	Cormogens.
;ens …………	Only a Thallus.	VIII.	Thallogens.

ıe Exogens and Endogens, the following subordinate series of subes are formed:—

nsolidated. Floral envelopes are united both with each other and the stamens, nd with the ovary.

parated. Floral envelopes and stamens are united to each other, but the ovary s consolidated and free.

lherent. Petals and sepals adhere to each other and the stamens, and ovary, ut have their parts disunited.

nited. Petals and sepals adhere to each other and the stamens, but have heir parts disunited, and do not adhere to the consolidated ovary.

solved. Petals and sepals are distinct from the stamens, and also from the vary, whose carpels are disunited, either wholly or by the styles.

ch of these subdivisions, the orders are arranged in two series, ne Albuminous, the other Exalbuminous.

782. LINDLEY'S DIVISION OF THE VEGETABLE KINGDOM. 1846.

ASEXUAL OR FLOWERLESS PLANTS.

nd leaves undistinguishable…………………………	Class I.	Thallogens.
nd leaves distinguishable……………………………	II.	Acrogens.

SEXUAL OR FLOWERING PLANTS.

Fructification springing from a thallus.. III. Rhi
Fructification springing from a stem.
  Wood of stem youngest in the centre, cotyledon single.
    Leaves parallel-veined, permanent, wood of stem always confused.. IV. End
    Leaves net-veined, deciduous, wood of stem, when perennial, arranged in a circle with a central pith........................ V. Dicty
  Wood of stem youngest at the circumference, always concentric, cotyledons two or more.
      Seeds quite naked.. VI. Gym
      Seeds enclosed in seed-vessels.. VII. Exog

The following are the subclasses of Endogens and Exogens adopt
Lindley:—

ENDOGENS.

Subclass 1. Glumaceous.—Floral envelopes imbricated.
——— 2. Petaloid.—Floral envelopes verticillate.
  a. Unisexual, often achlamydeous.
  b. Hermaphrodite, ovary adherent.
  c. Hermaphrodite, ovary free.

EXOGENS.

Subclass 1. Diclinous.—Flowers unisexual.
——— 2. Hypogynous.—Flowers usually hermaphrodite, stamens completely
  gynous, free from the calyx or corolla.
——— 3. Perigynous.—Flowers usually hermaphrodite, stamens growing to
  of either the calyx or corolla; ovary superior, or nearly so.
——— 4. Epigynous.—Flowers usually hermaphrodite, stamens growing to
  of either the calyx or corolla; ovary inferior, or nearly so.

Under the classes, Lindley enumerates 303 natural orders, whi
grouped together under 56 alliances. In this system of Lindle
divisions of Asexual and Sexual plants correspond to Endlich
Regions; the 7 classes represent Endlicher's 5 sections; and
alliances are equivalent to the 61 classes in Endlicher's system.

733. This division may be presented thus:—

Classes.	Wood.	Leaves.	Floral Envelopes.	Sexes.	Embryo.
1. Exogenæ	Exogenous	Netted	Quinary	Perfect	Dicotyledo
2. Gymnospermæ	Exogenous	Parallel or forked	None	Imperfect	Dicotyledo
3. Endogenæ	Endogenous	Parallel	Ternary	Perfect	Monocotyle
4. Dictyogenæ	Endogenous	Netted	Ternary	Perfect	Monocotyle
5. Rhizanthæ	None	None	Variable	Imperfect	Acotyledo
6. Acrogenæ	Acrogenous	Forked or None	None	None	Acotyledon
7. Thallogenæ	None	None	None	None	Acotyledon

Henslow has given a comparative view of all these sy
out, in a tabular form, the corresponding divisions in e

JUSSIEU, 1789.	DE CANDOLLE, 1819.	ENDLICHER, 1836.	LINDLEY, 1846.
	* Cellulares v. Acotyledoneæ.	* Thallophyta.	* Flowerless (alliances).
(algæ, 2.) lichenes. (fungi, 1.)	aphyllæ	I. PROTOPHYTA.	I. THALLOGENS... 1. algales. 3. lichenales. 2. fungales.
	ACOTYLEDONES.......IV.	II. HYSTEROPHYTA. * * Cormophyta.	
I. ACOTYLEDONES 1.................. (musci, 4) (hepaticæ, 3.)	foliosæ	1. Anophyta.	4. muscales.
	* * Vasculares v. Cotyledoneæ. † Monocotyledones v. Endogenæ.	III. ACROBRYA. 2. Protophyta.	II. ACROGENS. 5. lycopodales. 6. filicales.
(filices, 5.	MON. CRYPTOGAMÆ.......III.		* * Flowering.
		3. Hysterophyta.	III. RHIZOGENS.
II. MONOCOTYLEDONES. 2 4 3 (mono) -hypogynæ. -epigynæ. -perigynæ.	MON. PHANEROGAMÆ.....II.	IV. AMPHIBRYA.	IV. ENDOGENS and V. DICTYOGENS (11 alliances).
	† † Dicotyledones v. Exogenæ.	1. Gymnospermæ.	
III. DICOTYLEDONES. Diclines 4 irregulares 15 (-*gymnospermæ*.) (-*angiospermæ*.)			VI. GYMNOGENS.
1 Apetalæ 5 epi- 6 peri- 7 hypo- (-*stamineæ*.)	4. Monochlamydeæ....	2. Apetalæ.	1. Diclinous (8 alliances).
2 Monopetalæ 8 hypo- 9 peri- 10 *corisantheræ.* 11 *synantheræ.* epi- (-*corollæ*.)	3. Corollifloræ..		2. Hypogynous (14 alliances).
	DICOTYLEDONES I.	V. ACRAMPHIBRYA. 3. Gamopetalæ.	VII. EXOGENS.
	2. Calycifloræ...		3. Perigynous 10 alliances).
		4. Dialypetalæ.	4. Epigynous (17 alliances).
3 Polypetalæ 12 epi- 14 peri- 13 hypo- (-*petalæ*.)	1. Thalamifloræ.		

735. In the succeeding pages the natural orders will be grouped under the following divisions:—

A. Phanerogamous, or Vascular Flowering Plants.

Class I. Dicotyledones or Exogenæ.

Dichlamydeæ, having calyx and corolla.	Subclass 1. Thalamifloræ......Petals distinct, stamens hypogynous............	Polypetalæ of Jussieu, and Monopet. Peri- and Epi-corollæ.
	——— 2. Calycifloræ..........Petals distinct or united, stamens perigynous or epigynous	
	——— 3. Corollifloræ..........Petals united, Corolla hypogynous, usually bearing the stamens	Monopetalæ Hypocorollæ of Jussieu.
Having a single perianth.	———4. Monochlamydeæ...A calyx only, or none............................	Apetalæ and partly Diclines of Jussieu.
	a. Angiospermæ, seeds in an ovary.	
	b. Gymnospermæ, seeds naked.	

Class II. Monocotyledones or Endogenæ.

Subclass 1. Dictyogenæ.......... ....Floral envelopes verticillate, leaves reticulated.
——— 2. Petaloideæ or Floridæ, Floral envelopes verticillate, leaves parallel-vein
a. Hermaphrodite, ovary adherent.
b. Hermaphrodite, ovary free.
c. Unisexual, often achlamydeous.
——— 3. Glumiferæ ....Floral envelopes imbricated, leaves parallel-veined.

B. Cryptogamous, or Cellular Flowerless Plants.

Class III. Acotyledones or Acrogenæ.

Subclass 1. Ætheogamæ or Cormogenæ,..............................Having vascular ti
——— 2. Amphigamæ, Thallogenæ, or Cellulares..............Entirely cellular.

CHAPTER II.

ARRANGEMENT AND CHARACTERS OF THE CLASSES AND NATURAL ORDERS.

SECTION I.—PHANEROGAMOUS PLANTS.

Class I.—Dicotyledones and Exogenæ, *Juss.* and *DC.* Acramphibrya, *End*

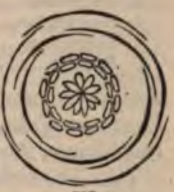
736. This is the largest class in the vegetable kingdom. The plants included under it have a *cellular* and *vascular* system, the latter consisting partly of elastic spiral vessels (fig. 49). *The stem* is more or less conical, and exhibits wood and true bark. *The wood* is exogenous, ncreases by additions at the periphery, the hardest part being al (¶ 72, &c.) It is arranged in concentric circles. Pith exists centre, and from it diverge medullary rays. *The bark* is separ- and increases by additions on the inside. *The epidermis* is fur-

ished with stomata (¶ 50). *The leaves* are reticulated (¶ 143,), usually rticulated to the stem. *The flowers* are formed upon a quinary r quaternary type, and have stamens and pistils. *The ovules* are ither enclosed in a pericarp, and fertilized by the application of the ollen to the stigma, or they are naked and fertilized by the direct ction of the pollen. *The embryo* has two or more opposite cotyledons, nd is exorhizal in germination (¶ 629).

Subclass 1.—THALAMIFLORÆ.*

737. Calyx and corolla present; petals distinct,† inserted into the halamus or receptacle; stamens hypogynous. This includes the ypogynous polypetalous orders of Jussieu, and a diclinous order Menispermaceæ).

738. Order 1.—**Ranunculaceæ**, the Crowfoot Family. (*Polypetalæ Hypogynæ.*) Sepals 3-6, frequently 5, deciduous fig. 556 *c*). Petals 5-15 (fig. 556 *p e*), rarely bortive, sometimes anomalous in form, (figs. 284 , 285), occasionally with scales at the base (fig. 55 *a*). Stamens usually indefinite, hypogynous fig. 556 *e*); anthers adnate (figs. 558, 559); car-els numerous, 1-celled (fig. 556 *p i*), distinct, or nited into a single many-celled pistil; ovary containng one anatropal ovule (figs. 492, 560 *g*), or several nited to the inner edge. Fruit various, either dry chænia (figs. 463, 561), or baccate or follicular (figs. 443, 468).



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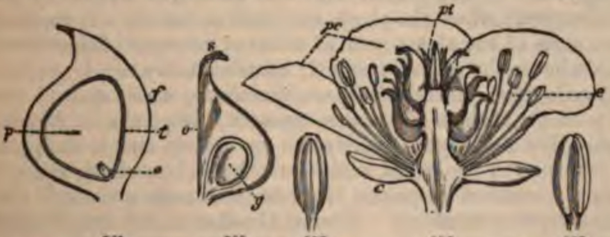

561 560 559 556 558

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* *Thalamus*, receptacle, and *flos*, flower.

† Sometimes the petals are abortive, and it is then difficult to determine whether the plant longs to this subclass or to Monochlamydeæ.

Figs. 556—561.—Exhibit the organs of fructification of Ranunculus acris, to illustrate the tural order Ranunculaceæ.

Fig. 556.—Flower cut vertically. *c*, Calyx. *pe*, Petals. *e*, Stamens. *pi*, Pistil composed o veral carpels on an elongated receptacle or axis.

Fig. 557.—Diagram of the flower, showing 5 imbricated sepals, 5 petals alternating with the als, indefinite stamens in several whorls, multiples of the petals, and numerous carpels or hænia in the centre.

Fig. 558.—Adnate anther seen on the outer side. The anther is in this instance extrorse. In onia and some Ranunculaceæ it is introrse.

Fig. 559.—Adnate anther viewed on the inside.

Fig. 560.—Vertical section of the ovary, *o*, showing the ovule, *g*. *s*, Stigma.

Fig. 561.—Fruit or achænium cut vertically. *f*, Pericarp. *t*, Spermoderm or integument of the atropal seed. *p*, Perisperm or albumen, between fleshy and horny. *e*, Minute embryo.

Seeds albuminous, erect, or pendulous; albumen horny (fig. 561 *p*); embryo minute (fig. 561 *e*).—Herbaceous, suffruticose, or rarely shrubby plants, having alternate or opposite, simple, much-divided leaves, with dilated sheathing petioles (fig. 233). Juice watery. Hairs, if present, simple.

739. The plants of the order are found in cold damp climates, and in the elevated regions of warm countries. Europe contains one-fifth of the order, and North America about one-seventh. The order is divided into five suborders:—1. Clematideæ; 2. Anemoneæ (fig. 247); 3. Ranunculeæ (fig. 233); 4. Helleboreæ (fig. 443); 5. Actææ, or Pæoniæ (fig. 370), according to the æstivation of the calyx, the nature of the fruit, &c. Henslow gives the following analysis of these suborders, with the number of British species in each:—

	Spec. Brit.	Anther.	Carpel.	Seed.	Æstiv.
1. Clematideæ.........	1	extrorse	mono-sperm.	•	valvate.
2. Anemoneæ..........	9			pendulous	imbricate.
3. Ranunculeæ.........	20			erect.	•
4. Helleboreæ..........	9		polysperm.	•	•
5. Pæoniæ..............	2	introrse	•	•	•

Authors enumerate 48 known genera, comprising 1060 species. *Examples of the genera*—Clematis, Anemone, Ranunculus, Helleborus, Delphinium, Aconitum, Actæa, Pæonia, Podophyllum.

740. The order has narcotico-acrid properties, and the plants are usually more or less poisonous. The acridity is frequently volatile, and disappears when the plants are dried or heated. It varies in different parts of the plants, and at different seasons. *Ranunculus* (the genus whence the order is named) contains many acrid species, such as *R. sceleratus, alpestris, bulbosus, gramineus, acris,* and *Flammula;* while others, such as *R. repens, aquatilis, Lingua,* and *Ficaria,* are bland. The acridity is entirely lost by drying, and it disappears in the pericarps as the seeds, which are themselves bland, ripen. The leaves of *Aconitum Napellus,* Monkshood, contain a narcotic alkaloid, called aconita or aconitina. They are used as an anodyne in neuralgic affections, in the form of extract and tincture. The root of *Aconitum ferox* furnishes the powerful East Indian poison, called Bikh or Nabee. The leaves of *Clematis recta* and *Flammula* have been used as vesicants. The seeds of *Delphinium Staphisagria,* Stavesacre, are irritant and narcotic, and are used for destroying vermin. They owe their activity to an alkaloid principle, called delphinia. The Hellebores have been long noted for their irritant qualities. *Helleborus officinalis, niger, fœtidus,* and *viridis,* act as drastic purgatives; hence the use of some of them in ancient times in cases of mania. The rhizome of *Podophyllum peltatum,* May-apple, is employed in America as a purgative. Some of the Ranunculaceæ are chiefly marked by bitter tonic properties. This order, in the position, number, and structure of its parts

f fructification generally, presents a resemblance to several widely iffering families. It differs from Dilleniaceæ, in the want of an aril, n its deciduous calyx, and in its whole habit; from Magnoliaceæ, in he want of true stipules; from Papaveraceæ and Nymphæaceæ, in the distinct, not united carpels, watery, not milky juice, and acrid, not narcotic properties. It closely approaches the Berberidaceæ, but differs in its stamens not bursting by recurved valves. In its numerous carpels, floral divisions, and indefinite stamens, it agrees with the Rosaceæ, but differs in its stamens being hypogynous instead of perigynous, in the large quantity of albumen surrounding the minute embryo, in the want of true stipules, and in its acrid properties. Crowfoots and Umbellifers agree in some particulars; the latter, however, have their calyx adherent to the ovary, and their stamens always definite.

741. Order 2.—**Dilleniaceæ**, the Dillenia Family. (*Polypet. Hypog.*) Sepals 5, persistent. Petals 5, deciduous, in a single row. Stamens indefinite, hypogynous, either distinct or combined into bundles; filaments dilated at the base or apex; anthers adnate, introrse, with longitudinal dehiscence. Ovaries definite, more or less distinct, with a terminal style and simple stigma; ovules ascending. Fruit of 2-5 capsular or baccate unilocular carpels, which are either distinct or coherent. Seeds universally arillate, several in each carpel, or only two, or one by abortion; testa (spermoderm) hard; embryo straight, minute, at the base of fleshy albumen.—The plants of the order are trees, shrubs, or under-shrubs, having alternate, exstipulate, coriaceous, or rough leaves. They are found chiefly in Australasia, Asia, and the warm parts of America. The Indian species are remarkable for their beauty, the grandeur of their foliage, and the magnificence of their flowers. They have astringent properties, and some of the species afford excellent timber. Authors enumerate 28 genera, including 206 species. *Examples*—Dillenia, Delima.

742. Order 3.—**Magnoliaceæ**, the Magnolia Family. (*Polypet. Hypog.*) Sepals 2-6, usually deciduous. Petals 2-30, hypogynous, often in several rows. Stamens indefinite, distinct, hypogynous; anthers adnate, long, dehiscing longitudinally. Carpels numerous, 1-celled, arranged upon a more or less elevated receptacle; ovules anatropal, suspended or ascending; styles short. Fruit consisting of numerous distinct or partially coherent carpels, which are either dehiscent or indehiscent, sometimes samaroid. Seeds, when ripe, often hang suspended from the carpels by a long slender cord; embryo minute, at the base of a fleshy perisperm.—Trees and shrubs, with alternate coriaceous leaves, and deciduous convolute stipules. They abound in North America, and some species occur in South America, China, Japan, New Holland, and New Zealand. The order has been divided nto two suborders:—1. Wintereæ; aromatic plants, in which the

leaves are dotted, the carpels are in a single verticil, and the wood often consists of punctated tissue (fig. 47). 2. Magnolieæ; bitter plants with fragrant flowers, in which the carpels are arranged in several rows on an elevated receptacle (fig. 306), and the leaves are not dotted. Authors mention 12 known genera, comprising 74 species. *Examples*—Illicium, Drimys, Magnolia, Liriodendron.

743. The properties of the order are bitter, tonic, and often aromatic. *Illicium anisatum*, Star-anise, is so called from its carpels being arranged in a star-like manner, and having the taste and odour of anise. Its fruit is employed as a carminative. *Drymis Winteri* or *aromatica*, brought by Captain Winter from the straits of Magellan in 1579, yields Winter's bark, which has been employed medicinally as an aromatic stimulant. It somewhat resembles Canella bark. *Magnolias* are remarkable for their large odoriferous flowers, and their tonic aromatic qualities. The bark of *Magnolia glauca*, Swamp Sassafras or Beaver-tree, is used as a substitute for Peruvian bark. *Liriodendron tulipifera*, the Tulip-tree, marked by its truncate leaves, has similar properties.

744. Order 4.—**Anonaceæ**, the Custard-apple Family. (*Polypet. Hypog.*) Sepals 3-4, persistent, often partially cohering. Petals 6, hypogynous, in two rows, coriaceous, with a valvate æstivation. Stamens indefinite (very rarely definite); anthers adnate, extrorse, with a large 4-cornered connective. Carpels usually numerous, separate or cohering slightly, rarely definite; ovules anatropal, solitary or several, erect or ascending. Fruit succulent or dry, the carpels being one or many-seeded, and either distinct or united into a fleshy mass; spermoderm brittle; embryo minute, at the base of a ruminated or mottled perisperm or albumen, which constitutes an important character of the order. Trees or shrubs, with alternate, simple, exstipulate leaves, found usually in tropical countries. Authors enumerate 23 genera, including 370 species. *Examples*—Bocagea, Anona, Uvaria, Guatteria, Xylopia, Duguetia.

745. Their properties are generally aromatic and fragrant. Some of the plants are bitter and tonic, others yield edible fruits. The custard-apples, Sweetsops, and Soursops of the East and West Indies, are furnished by various species of Anona, such as *A. squamosa*, *reticulata*, and *muricata*. *Anona cherimolia* furnishes the Cherimoyer, a well-known Peruvian fruit. The fruit of *Xylopia aromatica* is commonly called Ethiopian Pepper, from being used as pepper in Africa. *Xylopia glabra* is called Bitter-wood in the West Indies. The Lancewood of coachmakers appears to be furnished by a plant belonging to this order, called by Schomburgk *Duguetia quitarensis*.

746. Order 5.—**Menispermaceæ**, the Moon-seed Family. (*Polypet. Hypog.*) Flowers usually unisexual (often diœcious), generally of a pale-greenish hue. Sepals and petals similar in appearance, in one or

several rows, 3 or 4 in each row, hypogynous, deciduous. Stamens monadelphous, or occasionally free; anthers adnate, extrorse. Carpels solitary or numerous, distinct or partially coherent, unilocular; ovule solitary, curved (fig. 420). Fruit a succulent 1-seeded oblique or lunate drupe. Embryo curved or peripherical; radicle superior; albumen fleshy, sometimes wanting.—The plants of this order are sarmentaceous or twining shrubs, with alternate leaves, and very small flowers. The wood is frequently arranged in wedges, and hence the order was at one time put under the division called Homogens by Lindley (¶ 90 and 731). The order is common in the tropical parts of Asia and America. There are 63 known genera, including 342 species. *Examples*—Menispermum, Cissampelos, Cocculus, Lardizabala, Schizandra.

747. The species are bitter and narcotic. Some are employed as tonics, others have poisonous properties. The root of *Cocculus* (*Jateorhiza*) *palmatus*, a plant of east Africa, is known as Calumba-root, and is used as a pure bitter tonic in cases of dyspepsia, in the form of infusion or tincture. It contains a bitter crystallizable principle called Calumbin. Cocculus indicus is the fruit of *Anamirta paniculata*. It is extremely bitter. The seed contains a crystalline poisonous narcotic principle, Picrotoxin, which is its active ingredient; while the pericarp yields a poisonous alkaloid called Menispermine. It has been used externally in some cutaneous affections. At one time it was employed, most prejudicially, to give bitterness to porter. *Cissampelos Pareira*, Wild-vine or Velvet-leaf, furnishes Pareira-brava-root, which is employed as a tonic and diuretic, and has heen recommended in chronic inflammation of the bladder. *Cissampelos ovalifolia* and *C. Mauritiana* are used as tonics and diuretics. *Coscinium* (*Menispermum*) *fenestratum* supplies a false Calumba-root, which contains much Berberine, the same yellow bitter crystalline substance which is found in the Barberry.

748. Order 6.—**Berberidaceæ,** the Barberry Family. (*Polypet. Hypog.*) Sepals 3-4-6, deciduous, in a double row. Petals hypogynous, equal in number to the sepals, and opposite to them, or twice as many, often having an appendage at the base on the inside. Stamens equal in number to the petals, and opposite to them; anthers adnate, bilocular (dithecal), each of the loculi opening by a valve from the bottom to the top. Carpel solitary, unilocular, containing 2-12 anatropal ovules; style sometimes lateral; stigma orbicular. Fruit baccate or capsular, indehiscent. Albumen fleshy or horny; embryo straight, sometimes large (fig. 494).—Shrubs or herbaceous perennial plants with alternate, compound, exstipulate leaves. The true leaves are often changed into spines, by non-development of parenchyma and induration of the veins (fig. 231 *f*). Found chiefly in the mountainous parts of the temperate regions of the northern hemisphere. The plants of the order have bitter and acid properties. The bark

and stem of *Berberis vulgaris*, common Barberry, are astringent, and yield a yellow dye and a crystalline matter called Berberine; the fruit contains oxalic acid, and is used as a preserve. Lindley enumerates 12 genera, including 109 species. *Examples*—Berberis, Epimedium, Leontice.

749. Order 7.—**Cabombaceæ,** the Watershield Family. (*Polypet. Hypog.*) Sepals 3-4. Petals 3-4, alternate with the sepals. Stamens hypogynous, arising from an inconspicuous torus, two or three times the number of the petals; anthers linear, introrse, continuous with the filament. Carpels 2 or more; stigmas simple; ovules orthotropal. Fruit indehiscent, tipped with the indurated styles, containing one or two pendulous seeds. Embryo minute, enclosed in a vitellus (the sac of the amnios), and placed at the base of a fleshy perisperm.—American aquatic plants, with floating peltate leaves. Some have nutritious and slightly astringent properties, and have been used in phthisis and dysentery. Lindley mentions 2 genera, including 3 species. *Examples*—Hydropeltis, Cabomba.

750. Order 8.—**Nymphæaceæ,** the Water-lily Family (fig. 562) (*Polypet. Hypog.*) Sepals usually 4, sometimes confounded with the petals. Petals numerous, often passing gradually into stamens (fig. 310, 2). Stamens indefinite, inserted above the petals into the torus (fig. 562 *c*); filaments petaloid; anthers adnate, introrse, opening by two longitudinal clefts. Torus large, fleshy, surrounding the ovary more or less (fig 562 *t*). Ovary multilocular, many-seeded, with radiating stigmas (fig. 562 *s*); numerous anatropal ovules. Fruit many-celled, indehiscent. Seeds very numerous, attached to spongy dissepiments; albumen farinaceous; embryo small, enclosed in a fleshy vitellus, and situated at the base of the perisperm (fig. 480).—Aquatic plants, with peltate or cordate fleshy leaves, and a rootstock or stem which extends itself into the mud at the bottom of the water. Lindley enumerates 5 genera, comprehending 60 species. *Examples*—Nymphæa, Nuphar, Victoria, Euryale.

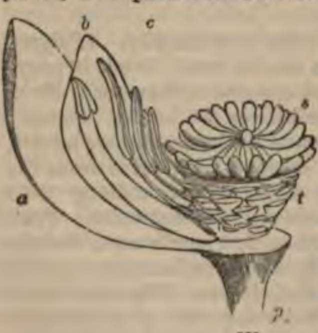

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Fig. 562.—Section of a flower of Nymphæa alba, white Water-lily, showing the pistils and the receptacle or torus bearing the stamens and petals. *p*, Peduncle or flower-stalk. *t*, Enlarged torus or receptacle. *s*, Radiating stigmas. *a*, Sepal. *b*, Petal. *c*, Stamens.

751. The plants of this order are found throughout the northern hemisphere, and are generally rare in the southern hemisphere. Little is known in regard to their properties. Some of them are astringent and bitter, while others are said to be sedative. They have showy flowers, and their petioles and

luncles contain numerous air-tubes. *Victoria regia* is one of the gest known aquatics. It is found in the waters of South America, l is said to range over 35 degrees of longitude. The flowers have ine odour. When expanded they are a foot in diameter. The ves are from four to six and a-half feet in diameter. The seeds and tstocks of many plants of this order contain much starch, and are d for food. It has been said that the rhizomes of *Nymphæa alba* better than Oak-galls for dyeing gray; they have been long em-yed advantageously for tanning leather. The stems of *Nuphar tum* are reported to be astringent.

752. Order 9.—**Nelumbiaceæ,** the Water-bean Family. (*Polypet. pog.*) Sepals 4-5. Petals numerous, in many rows. Stamens in-inite, in several rows; filaments petaloid; anthers adnate, introrse, ning by a double longitudinal cleft. Torus large, fleshy, elevated, losing in hollows of its surface numerous carpels. Nuts numerous, erted, but loose, into the depressions of the torus. Seeds 1-2; isperm none; embryo enclosed in a vitellus, large, with two fleshy yledons.—Aquatic herbs, with showy flowers, peltate floating leaves, l prostrate rootstocks, found in the temperate and tropical regions the old and new world. Lindley enumerates 1 genus, including 3 cies. *Example*—Nelumbium.

753. The flower of *Nelumbium speciosum* is supposed to be the Lotus red on Egyptian and Indian monuments, and the fruit is said to be Pythagorean Bean. The plant is said to have dissappeared from Nile, where it used to abound. The petioles and peduncles contain erous spiral vessels, which have been used for wicks of candles. Wight states that those wicks on great and solemn occasions are in the lamps of the Hindoos placed before the shrines of their

. Order 10.—**Sarraceniaceæ,** the Sidesaddle-flower Family. *et. Hypog.*) Sepals 5, persistent, imbricated in æstivation, with coherent bracts outside. Petals 5, hypogynous, concave: ally the corolla is absent, and the calyx consists of 4-6 ts. Stamens 00; anthers adnate, dithecal, introrse, with longi-dehiscence. Ovary free, tri-quinquelocular; style single; persistent, either a truncated point, or large and peltate with s; ovules anatropal. Capsule 3-5-celled, with loculicidal ce. Seeds very numerous, small, attached to large placentas roject from the axis into the cavity of the cells; albumen embryo cylindrical, lying at the base of the seed, radicle to the hilum.—Herbaceous plants, found in boggy places, dical leaves, the petioles of which are folded, and cohere so a ascidia or hollow tubes, which being lined by hairs of a ture, appear to act as secreting organs (fig. 187). Scapes e flowered. The plants are found in North America and

Guiana. Their properties are not known. There are 4 genera, including 9 species. *Examples*—Sarracenia, Heliamphora, Darlingtonia.

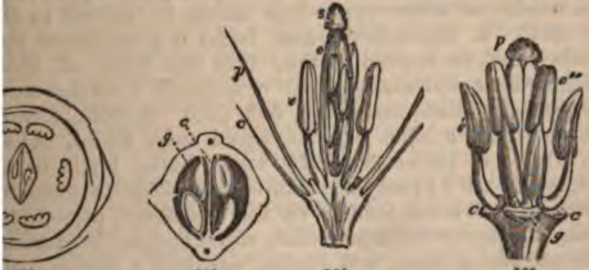
755. Order 11.—**Papaveraceæ,** the Poppy Family. (*Polypet. Hypog.*) Sepals 2, deciduous. Petals hypogynous, usually 4, cruciate, sometimes a multiple of 4, regular, rarely wanting. Stamens hypogynous, usually 00, sometimes a multiple of 4; anthers dithecal, innate. Ovary solitary, style short or none; stigmas 2, or many and radiating (fig. 409); ovules 00, anatropal (fig. 421). Fruit unilocular, either siliquæform with two, or capsular with several parietal placentas. Seeds numerous; albumen between fleshy and oily; embryo minute, at the base of the albumen, with plano-convex cotyledons.—Herbs or shrubs, usually with milky or coloured juice, having alternate exstipulate leaves, and long one-flowered peduncles. The plants belonging to this order are chiefly European. The species, however, are found scattered over tropical America, Asia, China, New Holland, Cape of Good Hope, &c. Lindley mentions 20 known genera, and 140 species. *Examples*—Papaver, Meconopsis, Eschscholtzia, Glaucium, Chelidonium.

756. The order possesses well-marked narcotic properties. Opium is the concrete milky juice procured from the unripe capsules of *Papaver somniferum*, and its varieties. The plant is a native of Western Asia, and probably also of the south of Europe; but it has been distributed over various countries. There are five kinds of opium known, viz. Turkey, Egyptian, East Indian, European, and Persian; of which the first is the kind chiefly used in Britain. The most important active principle in opium is the alkaloid called morphia. There are other crystalline principles found in it, such as codeia and narcotine; and an acid called meconic acid, which constitutes with sulphuric acid the solvent of the active principles. According to various circumstances, opium may act as a stimulant, a narcotic, anodyne, or diaphoretic. The seeds of the Opium Poppy yield a bland, wholesome oil. *Chelidonium majus*, Celandine, yields an orange-coloured juice, which is said to have acrid properties. In this plant, observations were made by Schultz on Cyclosis (¶ 261, and fig. 223). *Eschscholtzia* is remarkable for the dilated apex of the peduncle, from which the calyx separates in the form of a calyptra, resembling an extinguisher of a candle. *Sanguinaria canadensis*, Blood-root, or Puccoon, has emetic and purgative properties.

757. Order 12.—**Fumariaceæ,** the Fumitory Family. (*Polypet. Hypog.*) Sepals 2, deciduous. Petals 4, cruciate; one or both of the two outer gibbous at the base, the two inner cohering at the apex. Stamens hypogynous, usually 6, diadelphous; anther of middle stamen of each parcel bilocular, outer ones unilocular. Ovary free, 1-celled; style filiform; stigma with 2 or more points; ovules amphitropal. Fruit either an achænium, or a 1-celled 2-seeded, or 2-valved many-

›d. Seeds crested; albumen fleshy; embryo minute, ex- Herbaceous plants, with a watery juice, and alternate eaves. Although at first sight very unlike the Poppy family, tories resemble this order in their deciduous sepals, in their l, in many cases, in their fruit. The two outer unilocular of each parcel may be considered as forming one perfect hus making the whole number four. They are found chiefly rn temperate latitudes. Two are found at the Cape of Good 'hey are usually scentless, and are said to be bitter and dia- n their properties. The tuber of *Corydalis bulbosa* has been substitute for Birthworts in expelling intestinal worms, and as ıagogue. Authors notice 18 genera, including 134 species. —Fumaria, Corydalis, Diclytra.

'rder 13.—**Cruciferæ**, the Cruciferous or Cresswort Family. æ of Lindley. *(Polypet. Hypog.)* Sepals 4, deciduous, the l ones gibbous at the base. Petals 4, hypogynous, alternat- the sepals, deciduous, cruciate (fig. 291). Stamens 6, tetra- (figs. 345, 565), two shorter solitary (fig. 565 *e'*), opposite l sepals, occasionally toothed; four longer (fig. 565 *e''*), the anterior and posterior sepals, generally free, sometimes united and furnished with a tooth on the inside; anthers introrse (fig. 564). Torus with green glands between the d stamens and ovary (fig. 565 *g*). Ovary superior, with ›lacentas, which meet in the middle, forming a spurious dis- or replum (fig. 566 *c*); stigmas 2, opposite the placentas, or nd posterior (fig. 456 *s*). Fruit a siliqua (figs. 567, 568), ula, rarely 1-celled and indehiscent, usually spuriously

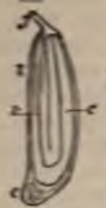


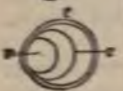
563 566 564 565

'0.—Organs of fructification of Erysimum lanceolatum, one of the Cruciferæ.
Diagram of the flower, showing the arrangement of four sepals, four petals alter- hem, six tetradynamous stamens, and a siliqua with replum.
Vertical section of the flower. *c*, Calyx. *p*, Petals. *e*, Stamens. *o*, Ovary laid ma.
Flower deprived of its envelopes. *c c*, Cicatrices left by the fall of the sepals. ich are situated at the base of the stamens. *e'*, Two short stamens opposite lateral our long stamens opposite anterior and posterior sepals. *p*, Pistil.
Horizontal section of the ovary. *g*, Ovules. *c*, Spurious dissepiment or replum, the ovary into two cavities. This replum is formed by the placentas.

2-celled and dehiscing by two valves, which separate from the replum (figs. 456, 568), one or many-seeded. Seeds Campylotropous (figs. 419, 524), pendulous, attached in a single row by a funiculus to each side of the placenta (fig. 568); perisperm none; embryo with the radicle folded upon the cotyledons which are next the placenta (figs. 524, 569 r).—Herbaceous plants seldom undershrubs, with alternate leaves, and yellow or white, rarely purple, flowers, without bracts. This order is well distinguished by having tetradynamous stamens. Most of the plants belonging to the order are European. The species, however, are found scattered all over the world. De Candolle, in 1821, calculated that the species then known were distributed as follows:—

569





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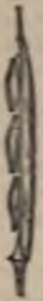


568

567

In the frigid zone of the northern hemisphere		205
In all the tropics (chiefly mountainous parts)		30
In the temperate zone,	of northern hemisphere.........548 of southern hemisphere........ 86	634

Authors enumerate 203 genera, including 1692 species. *Examples*—Draba, Lepidium, Isatis, Brassica, Sinapis, Bunias, Senebiera, Schizopetalon.

759. The order has been subdivided into sections, according to the mode in which the radicle of the embryo is folded on the cotyledons, as well as according to the nature of the fruit. The suborders founded on the embryo are—1. Pleurorhizeæ (πλευρά, side, and ῥίζα, root), 0 = cotyledons accumbent, radicle lateral, *i.e.* applied to their edge (fig. 517). 2. Notorhizeæ (νῶτον, back), 0 ‖ cotyledons incumbent, radicle dorsal, *i.e.* applied to their back (fig. 518). 3. Orthoploceæ (ὀρθός, straight, and πλόκος, a plait or fold), 0>> cotyledons conduplicate (folded), radicle dorsal (figs. 513, 570). 4. Spirolobeæ (σπεῖρα, a coil, and λοβός, a lobe), 0 ‖ ‖ cotyledons twice folded, radicle dorsal (fig. 515). 5. Diplecolobeæ (δίς, twice, πλέκω, I fold or plait, and λοβός, a lobe), 0 ‖ ‖ ‖ cotyledons three times folded, radicle dorsal.

760. The divisions founded on the seed-vessel, are—1. Siliquosæ, a siliqua, linear or linear-lanceolate, valves opening longitudinally. 2. Latiseptæ (*latus*, broad, and *septum*, partition), a silicula, partition in its broadest diameter, oval or oblong, valves flat or convex, opening longitudinally. 3 Angustiseptæ (*angustus*, narrow), a silicula, parti-

Fig. 567.—Siliqua or long pod.

Fig. 568.—Siliqua with one of its valves removed, in order to show the seeds attached to the replum.

Fig. 569.—Vertical section of the seed. *f*, Funiculus or umbilical cord. *t*, Spermoderm or testa swollen at the chalaza, *c*. *r*, Radicle. *c*, Cotyledons.

Fig. 570.—Horizontal section of the seed. *t*, Spermoderm or testa. *r*, Radicle. *c*, Incumbent cotyledons.

tion in its narrow diameter, linear or lanceolate, valves opening longitudinally, folded and keeled. 4. Nucumentaceæ (*nucumentum*, a nut), silicula, valves indistinct or indehiscent, often 1-celled, from the absence of the replum or partition. 5. Septulatæ (*septa*, partitions), valves opening longitudinally, furnished with transverse partitions in their interior. 6. Lomentaceæ (*lomentum*, an articulate legume), siliqua or silicula, dividing transversely into single-seeded cells, the true siliqua being often barren and all the seeds placed in the beak.

761. In this order there is a want of symmetry as regards the number of stamens, compared with the floral envelopes. The two long stamens placed close together may, however, be looked upon as one divided by a process of deduplication, so that the actual number will thus be reduced to four. This view is confirmed by the shorter stamens having teeth on each side, while the longer ones are toothed on one side only. By pelorization, too, some Cruciferæ become tetrandrous. While there is a splitting of the filaments, there is also the production of two additional anther-lobes. In regard to the fruit it has been stated, that normally there are four carpidia or carpels, two of which are constantly abortive. In some species of Iberis there have been seen four sepals, four petals, four stamens, and four carpels. Thus the floral type of Cruciferæ is quaternary: calyx having four sepals, corolla four petals, receptacle four staminiferous glands, andrœcium four stamens, gynœcium four phyllidia, fruit four carpidia.

762. There are no truly poisonous plants in the order. In general, it possesses antiscorbutic and stimulant qualities, with a certain degree of acridity. Many of the most common culinary vegetables belong to the order, such as Cabbages, Cauliflower, Turnip, Radish, Cress, Horseradish, &c. They contain much sulphur and nitrogen, and, on this account, when decaying, give off a disagreeable odour. Many garden flowers, such as Wall-flower, Stock, Rocket, and Honesty, are found in this order. *Brassica oleracea* is the original species whence all the varieties of Cabbage, Cauliflower, Brocoli and Savoys have been obtained by the art of the gardener. The part of the Cauliflower used as food is the deformed flower stalks. *Brassica Rapa* is the common Turnip, while *Brassica campestris* is the source of the Swedish Turnip. *Brassica chinensis* yields Shanghae oil. *Lepidium sativum* is the common Cress, and *Raphanus sativus* the Radish. *Crambe maritima* is the Sea-kale. The seeds of *Sinapis nigra* (*Brassica nigra* of some), furnish table mustard. These contain a bland fixed oil, a peculiar bitter principle, myronic acid, and another principle analogous to albumen or emulsin, called myrosine. When water is added, the myronic acid and myrosine, by their combination, form a pungent volatile oil, containing sulphur and nitrogen, which gives to mustard its peculiar properties as a physiological agent. *Sinapis alba* furnishes white mustard, which contains more fixed oil than black mustard. It does not, however,

contain myronic acid, but an analogous principle called sinapin, or sinapisin, which, by combination with another principle, forms an acrid compound, but not a volatile oil. The mustard of Scripture is not a species of Sinapis, but *Salvadora persica*, according to Royle, belonging to the natural order *Chenopodiaceæ*. Many other Cruciferous plants yield volatile oils containing sulphur, and the seeds of many yield by expression a bland fixed oil, such as Rape-seed oil. *Cochlearia officinalis*, common Scurvy-grass, is used as a stimulant. *Cochlearia Armoracia*, or *Armoracia rusticana*, the Horse-Radish, has irritant and even vesicant qualities. *Anastatica hierochuntina*, Rose of Jericho, is remarkable for the hygrometric property of the old withered annual stems, which are rolled up like a ball in dry weather, and drifted about by the winds in the deserts of Syria and Egypt. If rain falls, they resume their original direction. They thus continue for many years to curl up and expand, according to the state of the atmosphere. The genus *Schizopetalon* is remarkable on account of its tetracotyledonous (having four cotyledons) embryo. *Isatis tinctoria*, Woad, when treated like Indigo, yields a blue dye. *Isatis indigotica* is the Tein-Ching, or Chinese Indigo.

763. Order 14.—**Capparidaceæ**, the Caper Family. (*Polypet. Hypog.*) Sepals 4, often more or less cohering (fig. 554 *c*). Petals 4, sometimes 0, cruciate (fig. 554, *p*), usually unguiculate and unequal. Stamens hypogynous, 4, 6 (fig. 554 *e*), or 00, but in general some high multiple of four, placed on an elongated hemispherical and often glandular torus (fig. 554 *a g*). Ovary usually stalked (fig. 554 *s*); styles filiform, sometimes 0; ovules curved. Fruit unilocular, siliqueform and dehiscent, or fleshy and indehiscent, rarely monospermous, usually with two polyspermous placentas. Seeds generally reniform and exalbuminous; embryo curved; cotyledons foliaceous, flattish.—Herbs, shrubs, sometimes trees, with alternate, stalked, undivided, or palmate leaves, which are either exstipulate or have spines at their base. Capparids may be distinguished from Crucifers by their stamens being often indefinite, or, if definite, scarcely ever tetradynamous, while their seeds are generally reniform. They are found chiefly in warm countries, and are abundant in Africa. There are 33 genera, and 348 species. The order is divided into two suborders:—1. Cleomeæ, with capsular fruit. 2. Cappareæ, with baccate fruit. *Examples*—Cleome, Capparis.

764. The plants of this order have stimulant qualities. The flower-buds of *Capparis spinosa* furnish capers. The plant is a native of the south of Europe. It, or *C. ægyptiaca*, is the Hyssop (אזוב) of Scripture. Some species of *Cleome* and *Polanisia* are very pungent, and are used as substitutes for mustard. The pungency of some is so great that they act as blisters. The root of *Cleome dodecandra* is used as an anthelmintic.

765. Order 15.—**Resedaceæ**, the Mignonette Family. (*Polypet.*

og.) Calyx many-parted. Petals 4-6, unequal, entire, or lacerated, he latter case consisting of a broad scale-like claw with a much-ded limb. Stamens 10-24, hypogynous, attached to a glandular s; filaments variously united; anthers bilocular, innate, with itudinal dehiscence. Ovary sessile, 3-lobed, 1-celled, multiovular, 3-6 parietal placentas; stigmas 3. Fruit either a unilocular y-seeded capsule, opening at the apex so as to render the seeds nude (fig. 479), or 3-6 few-seeded follicles. Seeds reniform, lly exalbuminous; embryo curved; radicle superior; cotyledons hy.—Herbaceous plants, rarely shrubs, with alternate, entire, or ded leaves, having gland-like stipules. They inhabit chiefly Europe the adjoining parts of Asia. A few are found in the north of ia and south of Africa. The uses of the order are unimportant. *da Luteola*, Weld, yields a yellow dye. *Reseda odorata* is the rant Mignonette. The Mignonette is rendered suffruticose, by venting the development of its blossoms. This is the origin of the Mignonette, which is much cultivated in France. There are 6 wn genera, and 42 species, according to Lindley. *Example* eseda.

66. Order 16.—**Flacourtiaceæ,** the Arnotto Family. (*Polypet. Hy-*) Sepals 4-7, slightly cohering. Petals equal to and alternating the sepals, or wanting. Stamens hypogynous, equal in number he petals, or some multiple of them. Ovary roundish, sessile, or htly stalked; style either none or filiform; stigmas several, more ess distinct; ovules attached to parietal placentas, which some-es branch all over the inner surface of the valves. Fruit 1-celled, aining a thin pulp, either fleshy and indehiscent, or capsular with 5 valves. Seeds numerous, enveloped in a covering formed by withered pulp; albumen fleshy, somewhat oily; embryo axile, ight; radicle turned towards the hilum; cotyledons flat, foliaceous. hrubs or small trees, with alternate, simple, usually exstipulate es, which are often dotted. The plants are chiefly natives of the mest parts of the East and West Indies, and of Africa. The order ivided into two sections:—1. Flacourtieæ, having the placentas ifying over the inner surface of the fruit. 2. Bixeæ, placentas ow, and running in lines along the parietes. Many of the plants d edible fruits. The pulp is often sweet and wholesome. Some stringent, others purgative. The reddish pulp surrounding the s of *Bixa orellana* supplies the substance called arnotto, which is l for yielding a red colour, and for staining cheese. Martius says the seeds are cordial, astringent and febrifugal. There are 35 ra, and 97 species, according to authors. *Examples*—Patrisia, ourtia, Prockia, Erythrospermum, Bixa.

67. Order 17.—**Cistaceæ,** the Rock-Rose Family. (*Polypet. Hypog.*) ls usually 5, persistent, unequal, the three inner with contorted

æstivation. Petals 5, caducous, hypogynous, æstivation corrugated, and twisted in an opposite direction to that of the sepals. Stamens usually 00, free, hypogynous; anthers 2-celled, adnate. Ovary syncarpous, 1- or many-celled; style single; stigma simple. Fruit capsular, 3-5-10-valved, either 1-celled or imperfectly 5-10-celled, with loculicidal dehiscence. Seeds usually indefinite; embryo inverted, either spiral or curved, in the midst of mealy albumen; radicle remote from the hilum.—Shrubs or herbaceous plants with entire, opposite, or alternate, stipulate or exstipulate leaves. They inhabit chiefly the southern regions of Europe, and the north of Africa. Some of the species are remarkable for the irritability of their stamens (¶ 665). Many of them yield a resinous balsamic juice, which imparts viscidity to the branches. The resinous matter called ladanum or labdanum, is yielded by *Cistus creticus*. There are 8 known genera, and 189 species, according to authors. *Examples*—Cistus, Helianthemum, Lechea.

768. Order 18.—**Violaceæ**, the Violet Family. (*Polypet. Hypog.*) Sepals 5, persistent usually elongated at the base, æstivation imbricated. Petals 5, hypogynous, equal or unequal, generally withering, æstivation obliquely convolute. Stamens 5, alternate with the petals, sometimes opposite to them, inserted on a hypogynous torus; anthers dithecal, introrse, often cohering, with a prolonged connective sometimes spurred (fig. 343); filaments dilated, two of them in the irregular flowers having an appendage at their base. Ovary unilocular, with many (rarely one) anatropal ovules; style single, usually declinate, with an oblique hooded stigma (fig. 390, 1 *s*). Fruit a 3-valved capsule, dehiscence loculicidal, placentas on the middle of the valves (fig. 390). Seeds 00 or definite; embryo straight, erect, in the axis of a fleshy perisperm.—Herbs or shrubs, with alternate, rarely opposite, leaves, having persistent stipules, and an involute vernation. They are natives of Europe, Asia, and America. The herbaceous species inhabit chiefly the temperate parts of the northern hemisphere, while the shrubby species are found in South America and India. They have been divided into two suborders:—1. Violeæ, with irregular flowers. 2. Alsodeæ, with regular flowers. Their distinctive peculiarity may be regarded as resting in their definite stamens, whose anthers turn inwards, and extend their connective into a crest. There are 19 known genera, and 328 species. *Examples*—Viola, Ionidium, Alsodeia.

769. They are distinguished by the emetic properties of their roots, which contain an active principle called violine, similar in its qualities to emetin. Some species of *Ionidium* are used in South America as substitutes for Ipecacuan. The roots of *Viola odorata*, the Sweet or March Violet, the ἴον of the Greeks, have been used medicinally as an emetic; the petals are laxative, and are used in the form of infu-

d with sugar; and a violet or purple colouring matter is
from them, which is employed as a test for acids and
eing changed into red by the former, and into green by the
iola tricolor, Heart's-ease, and other species, have been used
ent expectorants. *V. tricolor* is the origin of all the culti-
ieties of pansy.

Order 19.—**Droseraceæ**, the Sundew Family. (*Polypet.*
Sepals 5, persistent, equal, æstivation imbricated. Petals
nous. Stamens free, withering, alternate with the petals, or
re; anthers bilocular, with longitudinal dehiscence. Ovary
yles usually 3-5, sometimes 1 or wanting. Fruit, a uni-
r spuriously trilocular capsule, 3-5-valved, with loculicidal
e, occasionally indehiscent. Seeds numerous, either al-
or exalbuminous; embryo minute and erect.—Herbaceous
h alternate leaves, usually inhabiting marshy places. They
in various parts of the world, in Europe, North and South
China, East Indies, &c. The order has been divided into
ns:—1. Drosereæ, styles 3-5, albumen present, leaves with
e vernation, and furnished with glandular hairs; stipules in
of fringes. 2. Parnassieæ, some of the stamens sterile;
r none; no albumen nor glandular hairs. There are 8
enera, and upwards of 90 species. *Examples*—Drosera,
da, Dionæa, Parnassia.

he *Droseras* have a more or less acid taste, combined with
idity. Some of them are said to be poisonous to cattle.
ves are furnished with glandular capitate hairs, which are
ith drops of fluid in sunshine; hence the name Sundew or
An Italian liqueur, called Rossoli, derives its name from a
used in its manufacture. Some of the Droseras have dyeing
. *Dionæa muscipula*, Venus's fly-trap, is a North American
ing the laminæ of the leaves in two halves, each furnished
e irritable hairs, which, on being touched, cause the folding
isions in an upward direction (fig. 186, ¶ 664). *Aldrovan-
ulosa*, an aquatic found in the South of Europe, is dis-
d by its whorled cellular leaves, or floating bladders. *Par-
lustris*, Grass of Parnassus, has remarkable gland-like bodies
the stamens (fig. 304). These are probably an abortive
he staminal organs. Lindley looks upon them as bundles of
and places the genus among Hypericaceæ. The stamens of
are irritable, and move towards the pistil in succession

Order 20.—**Polygalaceæ**, the Milkwort Family. (*Polypet.*
Sepals 5, very irregular, distinct; 3 exterior, of which 1 is
and 2 inferior; 2 interior, usually petaloid, lateral; æsti-
bricated. Petals hypogynous, unequal, usually 3, of which

1 is anterior, and larger than the rest, and 2 are alternate with the upper and lateral sepals; sometimes there are 5 petals, 2 of them very minute; the anterior petal, called the keel, is often crested. Stamens hypogynous, 8, monadelphous or diadelphous; anthers clavate, usually 1-celled, and having porous dehiscence. Ovary mostly bilocular; ovules solitary, rarely 2; style simple, curved; stigma simple. Fruit dehiscing in a loculicidal manner, or indehiscent. Seeds pendulous, anatropal, strophiolate at the hilum; albumen fleshy; embryo straight.—Shrubs or herbs with alternate or opposite exstipulate leaves. They are found in all quarters of the globe. Authors mention 21 genera, including 503 species. *Examples*—Polygala, Securidaca, Krameria.

773. In the appearance of their flowers, the plants of this order have a resemblance to Papilionaceæ. They are distinguished, however, by the odd petal being inferior, and the sepal superior. They are generally bitter, and their roots yield a milky juice. *Polygala Senega*, Snake-root, is a North American species, the root of which is used medicinally, in large doses, as emetic and cathartic; and in small doses as a stimulant, sudorific, expectorant, and sialagogue. It contains an acrid principle, called polygalin, senegin, and polygalic acid. The name of Snake-root was given from its supposed use as an antidote to the bite of the rattle-snake. *Krameria triandra*, a Peruvian plant, furnishes Rhatany-root, which is employed as a powerful and pure astringent in cases of hæmorrhage, and chronic mucous discharges. Its infusion is of a blood-red colour, and has been employed to adulterate port wine.

774. Order 21.—**Tremandraceæ**, the Porewort family. (*Polypet. Hypog.*) Sepals 4-5, slightly coherent, deciduous, with a valvate æstivation. Petals 4-5, deciduous, with an involute æstivation. Stamens hypogynous, distinct, 8-10, 2 before each petal; anther di- or tetra-thecal, with porous dehiscence (fig. 324). Ovary bilocular, with 1-3 pendulous ovules in each cell; style, 1; stigmas 1-2. Fruit a 2-celled, 2-valved capsule, with loculicidal dehiscence. Seeds anatropal, pendulous, with a caruncula at the apex; embryo cylindrical, straight, in the axis of fleshy albumen.—Heath-like shrubs, with hairs usually glandular, alternate or verticillate exstipulate leaves, and solitary axillary 1-flowered pedicels. They are natives of New Holland. Nothing is known regarding their properties. Authors mention 3 genera, including 17 species. *Examples*—Tetratheca, Tremandra.

775. Order 22.—**Tamaricaceæ**, the Tamarisk Family. (*Polypet. Hypog.*) Calyx 4-5 partite, persistent, with imbricated æstivation. Petals 4-5, hypogynous, or perhaps inserted at the base of the calyx, marcescent, with imbricated æstivation. Stamens hypogynous, free or monadelphous (fig. 311), equal to the petals in number, or twice as

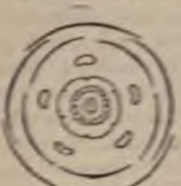
many; anthers dithecal, introrse, with longitudinal dehiscence. Ovary unilocular; styles, 3. Fruit a 3-valved, 1-celled capsule, with loculicidal dehiscence. Seeds numerous, anatropal, erect or ascending, comose; albumen 0; embryo straight, with the radicle next the hilum. —Shrubs or herbs, with alternate scale-like leaves, and racemose or spiked flowers. They abound in the Mediterranean region, and are confined chiefly to the eastern half of the northern hemisphere. Many are found in the vicinity of the sea. They have a bitter astringent bark, and some of them yield a quantity of sulphate of soda when burned. The saccharine substance called Mount Sinai Manna, is yielded by *Tamarix mannifera.* Lindley mentions 3 genera, comprising 48 known species. *Examples*—Tamarix, Myricaria.

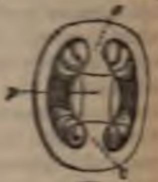
776. Order 23.—**Frankeniaceæ,** the Frankenia Family. (*Polypet. Hypog.*) Sepals 4-5, cohering into a tube, persistent. Petals 4-5, alternate with the sepals, hypogynous. Stamens hypogynous, equal in number to the petals, and alternate with them, sometimes more numerous; anthers bilocular, with longitudinal dehiscence. Ovary unilocular, with parietal placentas; style filiform, often trifid. Fruit a 1-celled, usually 3-valved capsule, with septicidal dehiscence. This latter distinguishes them from the Violet-worts to which they are allied. Seeds very minute, numerous, anatropal; embryo straight, in the axis of fleshy albumen.—Herbs or undershrubs, with opposite exstipulate leaves. They are found chiefly in the southern parts of Europe, and in the north of Africa. Two species are natives of the Cape of Good Hope, one of South America, four of New Holland, and three of temperate Asia. None have been found in tropical India, or North America. They are said to have mucilaginous and slightly aromatic properties. Genera, 4; species, 24. *Example*—Frankenia.

777. Order 24.—**Elatinaceæ,** the Water-pepper Family. (*Polypet. Hypog.*) Sepals 3-5, free, or slightly coherent at the base. Petals alternate with the sepals, hypogynous. Stamens hypogynous, equal to, or twice as many as, the petals. Ovary tri-quinquelocular; styles 3-5; stigmas, capitate. Fruit capsular, 3-5-celled, 3-5-valved, loculicidal; placenta central. Seeds 00, exalbuminous, anatropal; embryo cylindrical and slightly curved.—Annual marsh plants, with hollow creeping stems, and opposite stipulate leaves. They are found in all parts of the globe. Some of them have acridity, and hence the name Water-pepper. Genera 6, and species 22, according to Lindley. The Elatines are natives of Europe and Asia, Bergias of the Cape of Good Hope and the East Indies, Merimea of South America, and Tetradiclis of the Syrian region. *Examples*—Elatine, Bergia, Merimea, Tetradiclis.

778. Order 25.—**Caryophyllaceæ,** the Chickweed Family. (*Polypet. Hypog.*) Sepals 4-5 (fig. 571), free (fig. 269), or united in a tube (figs. 290 *c*, 553 *c*), persistent. Petals 4-5 (fig. 571), hypogynous,

unguiculate (fig. 281), often bifid or bipartite (fig. 283), occasionally 0. Stamens (fig. 572 *e*) usually double the number of the petals, or, if equal, usually alternate with them; filaments subulate, sometimes united; anthers innate, bilocular, dehiscence longitudinal. Ovary





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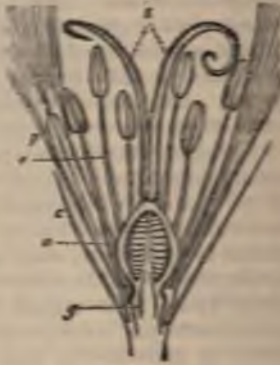

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single, often stalked or supported on a gynophore (fig 553 *g*), composed of 2 to 5 carpels, which are usually united by their edges, but sometimes the edges are turned inwards, so as to form partial dissepiments; stigmas 2-5 (fig. 391 *s*), with papillæ on their inner surface (fig. 572 *s*). Capsule unilocular (figs. 391, 574, 2), or imperfectly bi-quinquelocular (fig. 573), 2-5 valved, opening either by valves, or more commonly by twice as many teeth as stigmas (figs. 444, 574); placenta in the axis of the fruit (figs. 391, 574, 2, *p*). Seeds usually 00, amphitropal with mealy albumen, and a peripherical embryo (fig. 575).—Herbs, sometimes suffruticose plants, with opposite, entire, exstipulate, sometimes connate leaves, and usually cymose inflorescence (figs. 249, 250.)

Fig. 571-575.—Illustrations of the natural order Caryophyllaceæ.

Fig. 571.—Diagram of the flower of Alsine media, common Chickweed, belonging to the natural order Caryophyllaceæ, suborder Alsineæ. The flower consists of five imbricate sepals, five alternate petals, five stamens, a unilocular ovary, with a free central placenta, and numerous ovules.

Fig. 572.—Section of the flower of Dianthus Caryophyllus, Carnation. *c*, Calyx; *p*, petals cohering with the stamens at the base; *e*, stamens; *g*, gynophore or thecaphore, i.e. the stalk supporting the ovary; *o*, ovary with central placenta and ovules; *s*, two stigmas, which are papillose all along their inner surface.

Fig. 573.—Horizontal section of the ovary in a very young state, showing the partitions, *t t*, which divide the ovary into two cavities. These divisions ultimately disappear, leaving the placenta, *p*, bearing the ovules free in the centre.

Fig. 574.—Capsule of Lychnis Githago at the period of dehiscence, when the pericarp separates into five valves at the summit. 1. The capsule entire. 2. Capsule cut vertically, to show the seeds, *g*, grouped in a mass, on a free central placenta, *p*.

Fig. 575.—Seeds. 1. Entire seed. 2. Seed cut vertically. *t*, Spermoderm. *e*, Peripherical embryo, surrounding the mealy perisperm, *p*.

They inhabit chiefly temperate and cold regions. According to the calculation of Humboldt, Cloveworts constitute $\frac{1}{27}$ of the flowering plants of France, $\frac{1}{27}$ of Germany, $\frac{1}{17}$ of Lapland, and $\frac{1}{73}$ of North America. Those found within the tropics are usually met with on high elevations and mountainous tracts, many of them exclusively vegetate in regions of the lowest temperature. The order has been divided into three suborders:—1. Alsineæ, sepals distinct (fig. 269), and opposite the stamens, when the flowers are isostemonous. 2. Sileneæ, sepals cohering in a tube (fig. 290 *c*), opposite the stamens, when the flowers are isostemonous. 3. Mollugineæ, sepals distinct or nearly so, alternate with the stamens, when isostemonous. Authors mention 59 genera, and 1100 species. *Examples*—Alsine, Cerastium, Dianthus, Silene, Mollugo.

779. The plants of this order are usually insipid, but according to Malapert and Bonnet, some are poisonous. The poisonous quality is attributed by them to the principle called Saponine, which exists in many of the species of *Saponaria*, *Silene*, *Lychnis*, and *Dianthus*. To Saponine, also, is due the saponaceous or soap-like properties of the plants. *Honkeneja peploides* has been used as a pickle. In Iceland it serves as an article of food. The greater part of the plants of the order are weeds, but some are showy garden flowers. To the latter may be referred all the varieties of *Dianthus Caryophyllus*, Clove-pink or Carnation, Picotees, Bizarres, and Flakes, numerous species of Pink, Campion, &c. The varieties of Carnation depend on the mode in which the coloured stripes or dots are arranged on the petals, and the entire or serrated appearance of their edges. The formation of the placenta in the Caryophyllaceæ has given rise to much discussion, some looking upon it as a marginal, others as an axile formation (¶ 443).

780. Order 26.—**Vivianiaceæ,** the Viviania Family. (*Polypet. Hypog.*) Sepals 5, united. Petals 5, hypogynous, unguiculate, persistent, with twisted æstivation. Stamens 10, hypogynous; filaments free; anthers bilocular, opening longitudinally. Ovary free, 3-celled; stigmas 3. Capsule 3-celled, 3-valved, loculicidal; seeds, 2 in each cell, with a curved embryo lying among fleshy albumen.—Herbaceous or suffruticose plants, with opposite or verticillate exstipulate leaves. All the members of this order which have yet been discovered inhabit Chili and South Brazil. They have no properties of importance. Genera, 4; species, 15. *Examples*—Viviania, Cæsarea.

781. Order 27.—**Malvaceæ,** the Mallow Family. (*Polypet. Hypog.*) Sepals 5 (fig. 577), rarely 3 or 4, more or less cohering at the base (fig. 274 *c*), with a valvate æstivation (fig. 263), often bearing an external calyx (*epicalyx*) or involucre (fig. 274 *b*). Petals equal in number to the sepals; æstivation twisted (fig. 264). Stamens 00 (fig. 578 *a*), hypogynous, all perfect; filaments monadelphous (fig. 578 *t*) or

polyadelphous (fig. 551); anthers monothecal (fig. 328), reniform (fig. 579), with transverse dehiscence. Ovary formed by the union of several carpels round a common axis (figs. 452, 580), either distinct or cohering; styles as many as the carpels (fig. 578 *s*), united or free. Fruit capsular or baccate; carpels one or many-seeded, sometimes closely united, at other times separate or separable (figs. 383, 580); dehiscence loculicidal (fig. 449), or septicidal. Seeds amphitropal or semi-anatropal; albumen 0, or in very small quantity; embryo

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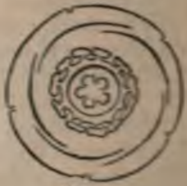

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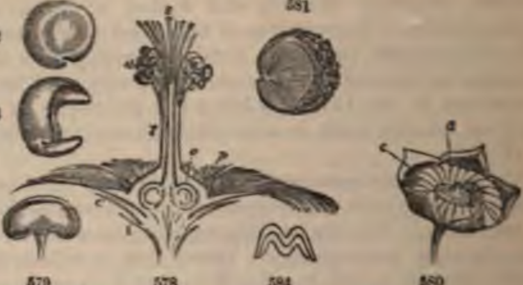


Figs. 576-584.—Organs of fructification of Malva sylvestris, to illustrate the natural order Malvaceæ.

Fig. 576.—Flower viewed from above, with its five petals, monadelphous stamens, peduncle or flower-stalk, and two stipules, *s*.

Fig. 577.—Diagram of the flower, showing the different whorls or verticils; five valvate or induplicate sepals, five twisted petals, indefinite monadelphous stamens, and united carpels.

Fig. 578.—Vertical section of the flower. *i*, Caliculus, epicalyx, or involucre; *c*, calyx; *p*, petals; *t*, tube of monadelphous stamens, forming an arch above the ovary, *o*, and united at the base to the petals; *a*, anthers at the summit of the filaments, free; *s*, styles free at the summit, united below.

Fig. 579.—A reniform monothecal anther, dehiscing transversely, separated with the upper part of the filament.

Fig. 580.—Fruit, surrounded by the persistent calyx, *c*, consisting of whorled carpels united together by the axis. *a*.

Fig. 581.—A separate carpel viewed laterally.

Fig. 582.—Exalbuminous amphitropal seed.

Fig. 583.—Curved embryo.

Fig. 584.—Section of the embryo, to show the doubled cotyledons.

curved (fig. 583); cotyledons twisted or doubled (fig. 584).—Herbaceous plants, trees or shrubs, with alternate stipulate leaves (fig. 576 *s*), more or less divided, and often with stellate hairs (fig. 82). They are found chiefly in tropical countries, and in the warm parts of the temperate zone. This family is closely related to the Sterculiads, including which they have been calculated to form $\frac{1}{86}$ of the flowering plants in Sicily, $\frac{1}{143}$ in France, $\frac{1}{233}$ in Sweden. In Lapland they are unknown. They form $\frac{1}{123}$ of those plants met with in temperate parts of North America, $\frac{1}{47}$ in the equinoctial parts of the same continent; taking into account the vegetation of the valleys, they, according to Humboldt, form $\frac{1}{30}$ of the flowering plants in the tropics, $\frac{1}{200}$ in the temperate zone, and are not found in the frigid zone. Authors enumerate 43 genera, including 1050 species. The order has been divided into three tribes:—1. Malveæ, an involucre present; fruit apocarpous or separable. 2. Hibisceæ, an involucre; fruit syncarpous. 3. Sideæ, no involucre; fruit either apocarpous or syncarpous. *Examples*—Lavatera, Malva, Hibiscus, Sida.

782. The plants of the order are all wholesome, and yield mucilage in large quantity. Some furnish materials for cordage, others supply cotton. *Malva sylvestris*, Common Mallow, and *Althæa officinalis*, Marsh Mallow, are employed medicinally, as demulcents and emollients. The latter is the Guimauve of the French. The flowers of *Althæa rosea*, the Hollyhock, are officinal in Greece for similar purposes; the plant also yields fibres and a blue dye. The petals of *Malva Alcea*, and *Hibiscus Rosa-sinensis*, possess astringent properties; the Chinese make use of them to blacken their eyebrows and the leather of their shoes. The flowers of *Abutilon esculentum*, and the fruit of *Abelmoschus esculentus*, called Ochro, are used as articles of food. *Hibiscus cannabinus* is the source whence sun-hemp is procured in India. Other species of *Hibiscus* as well as *Paritium tiliaceum* yield useful fibres. The bark of *Paritium elatum* furnishes Cuba Bast. Cotton is composed of the hairs surrounding the seeds of various species of *Gossypium*. These hairs, when dry, exhibit under the microscope a peculiar twisted appearance. *Gossypium barbadense* seems to be the species which yields the best cotton; the Sea-Island, New Orleans, and Georgian cotton being produced by varieties of it. *Gossypium peruvianum* or *acuminatum* furnishes the South American cotton; *Gossypium herbaceum*, the common cotton of India. *G. arboreum* is the Indian-tree cotton. The Chinese Nankin cotton is furnished by a variety of *G. herbaceum*. The quality of cotton-wool depends on the length, strength, and firmness of the tissue, or, as it is called, the *staple*. These essential attributes are modified by the cleanliness and the colour. Long-stapled cottons are generally used for the twist or warp, and short-stapled for the weft. The value of cotton varies not only according to the species,

filaments variously united; anthers 2-celled, extrorse. Pi
(rarely 3) carpels, either distinct or cohering; styles equal in
to the carpels, free or cohering; ovules orthotropal (fig. 523
tropal. Fruit capsular, usually with 5 cells, or follicular
culent. Seeds often with a woolly covering; with a flesh
perisperm (rarely 0), and either a straight or a curved
cotyledons leafy or thick, plaited or rolled round the pl
Trees or shrubs, with alternate leaves, which are either s
compound, deciduous stipules, and often a stellate pubescenc
are distinguished from Malvaceæ by their dithecal extrorse
They inhabit warm climates. The order has been divided
following sections:—1. Bombaceæ, with hermaphrodite flo
palmate or digitate leaves; found most abundantly in
2. Helictereæ, with hermaphrodite flowers and simple leave
rently unknown in Africa. 3. Sterculieæ, with unisexual
and either simple or palmate leaves; chiefly in India an
Authors mention 37 genera, including 138 species. *Ex*
Bombax, Helicteres, Sterculia.

784. The plants are mucilaginous and demulcent; many
for food, others supply a material like cotton. The silky h
rounding the seeds of *Bombax Ceiba*, the Silk-cotton tree, are
stuffing cushions and chairs, and for various other domestic
They cannot be manufactured. in consequence of no adhesion
between the hairs. The trunk of the tree is made into canoes.
sonia digitata, the Baobab tree of Senegal, or monkey-bread,
the largest known trees. Its trunk sometimes attains a dia
thirty feet, while its height is by no means in proportion. T
of its fruit (amphisarca) is used as an article of food. It is

temon platanoides is called the Hand-plant of Mexico, on account of its five peculiarly curved anthers, which resemble a claw. *Helicteres* (from *helix*, a snail) is so named on account of its twisted fruit. The Kola, mentioned by African travellers as being used to sweeten water, is the seed of *Sterculia tomentosa* or *acuminata.*

785. Order 29.—**Byttneriaceæ**, the Byttneria and Chocolate Family. (*Polypet. Hypog.*) Calyx 4-5 lobed, valvate in æstivation (fig. 261 *c*). Petals 4-5 or 0, often elongated at the apex, with a twisted or induplicate æstivation (fig. 261 *p*). Stamens hypogynous, either equal in number to the petals, or some multiple of them, more or less monadelphous, some of them sterile; anthers bilocular, introrse. Ovary free, composed usually of 4-10 carpels arranged round a central column; styles terminal, as many as the carpels, free or united; ovules 2 in each loculament. Fruit capsular, either with loculicidal dehiscence, or the carpels separating from each other. Seeds anatropal, often winged; embryo straight or curved, lying usually in fleshy albumen; cotyledons either plaited or rolled up spirally.—Trees, shrubs or undershrubs, with alternate leaves, having either deciduous stipules or 0, and stellate or forked hairs. They abound in tropical climates. Authors enumerate 48 genera, embracing 413 species. Byttneriads are often united with Sterculiads, from which they are distinguished by their slightly monadelphous stamens, and anthers turned inwards. Their two-celled anthers and not columnar stamens distinguish them from Mallow-worts. The order has been divided into six suborders founded on the following genera: *Examples*—Lasiopetalum, Byttneria, Hermannia, Dombeya, Eriolæna, and Philippodendron.

786. The plants abound in mucilage, and many yield cordage. The seeds of *Theobroma Cacao* are called Cacao-beans, and are the chief ingredient in chocolate, which contains also sugar, arnotto, vanilla, and cinnamon. The seeds by pressure yield a fatty oil, called Butter of Cacao. They contain a crystalline principle analogous to caffeine, called Theobromine. The *Cocoa* of the shops consists generally of the roasted beans, and sometimes of the roasted integuments of the beans ground to powder.

787. Order 30.—**Tiliaceæ**, the Lime-tree Family. (*Polypet. Hypog.*) Sepals 4-5, with a valvate æstivation. Petals 4-5, entire, rarely wanting. Stamens hypogynous, free, or united by the enlarged border of the stalk of the pistil (fig. 316, 1, 2), usually ∞; anthers 2-celled, dehiscing longitudinally or by pores, occasionally some abortive (fig. 316, 2). Disk often large and glandular. Ovary solitary, formed by the union of 2-10 carpels; style 1; stigmas as many as the carpels. Fruit dry or pulpy, either multilocular with numerous seeds, or by abortion unilocular and 1-seeded. Seeds anatropal; embryo erect in the axis of fleshy albumen, with flat, leafy cotyledons (fig. 510).—Trees or shrubs, rarely herbaceous plants, with alternate stipulate leaves (fig. 195).

The principal part of the order is found within the tropics forming weed-like plants, or shrubs, or trees, with handsome, usually white or pink flowers. A small number are peculiar to the northern parts of either hemisphere, where they form timber trees. The order has been divided into two sections:—1. Tilieæ, with entire petals or 0, and anthers dehiscing longitudinally. 2. Elæocarpeæ, with lacerated petals, and anthers opening at the apex. Authors enumerate 41 genera, including 363 species. *Examples*—Tilia, Corchorus, Grewia, Aristotelia, Elæocarpus.

788. The plants possess mucilaginous properties, and many of them furnish excellent materials for cordage. The fruit of some is edible. From the gummy matter they contain, some have been employed as demulcents. The inner bark, the bast or bass, of the Linden or Lime-tree (*Tilia Europæa*), is tough and fibrous, and from it are manufactured Russian mats. The bark of *Luhea grandiflora* is used in Brazil for tanning leather. An infusion of the flowers is used on the continent as an antispasmodic and expectorant. *Corchorus capsularis* in India furnishes Jute used for coarse carpets and gunny bags. The leaves of *Corchorus olitorius*, Jew's-mallow, are used as a culinary vegetable. *C. pyriformis* yields fibres in Japan.

789. Order 31.—**Dipterocarpaceæ**, the Sumatra-Camphor Family. (*Polpet. Hypog.*) Calyx tubular, 5-lobed, unequal, naked, persistent, and afterwards enlarged, with an imbricated æstivation. Petals hypogynous, sessile, often combined at the base, with a twisted æstivation. Stamens indefinite, hypogynous; filaments dilated at the base, either distinct or irregularly cohering; anthers innate, bilocular, subulate, opening by terminal fissures. Torus not enlarged in a disk-like manner. Ovary superior, 3-celled; ovules in pairs, pendulous; style and stigma simple. Fruit coriaceous, unilocular by abortion, 3-valved or indehiscent, surrounded by the calyx, which is prolonged in the form of long wing-like lobes. Seed solitary, exalbuminous; cotyledons often twisted and crumpled; radicle superior.—Trees with alternate leaves, having an involute vernation, and deciduous convolute stipules. They are found in India and especially in the eastern islands of the Indian Archipelago, where, according to Blume. they form the largest trees of the forest. There are about 9 known genera, including 57 species. *Examples*—Dipterocarpus, Vateria, Dryobalanops.

790. The trees belonging to this order are handsome and ornamental, and they abound in resinous juice. A kind of Camphor is procured in Sumatra from *Dryobalanops Camphora* or *aromatica*. It is secreted in crystalline masses naturally into cavities in the wood. It is less volatile than the common camphor of commerce. It supplies this camphor only after attaining a considerable age. In its young state it yields on incision a pale yellow liquid, called the liquid camphor of Borneo and Sumatra, which consists of resin and a volatile oil

aving a camphoraceous odour. Indian copal, or Gum animi of comnerce, is the inspissated varnish got from *Vateria Indica*. The fruit f this tree yields to boiling water the celebrated butter of Canara, or Pinei tallow. Various species of *Dipterocarpus* yield a substance like Balsam of Copaiva. *D. turbinatus* yields wood-oil.

791. Order 32.—**Chlænaceæ**, the Chlænad Family. (*Polypet. Hygog.*) Involucre 1-2-flowered, persistent. Sepals 3, small. Petals 5-6, hypogynous, sometimes combined at the base where they are broader. Stamens 10, or indefinite; filaments cohering at the base, and united to the base of the petals; anthers roundish, free or united, bilocular. Ovary single, trilocular; style 1, filiform; stigma trifid. Capsule 3-celled, or by abortion 1-celled. Seeds solitary or numerous, suspended, attached to a central placenta; embryo in the axis of fleshy or horny albumen; cotyledons leafy, undulated.—Trees or shrubs, with alternate stipulate leaves, found in Madagascar. Their properties are unknown. There are four genera enumerated, including probably about 8 or 10 species. *Examples*—Sarcolæna, Leptolæna.

792. Order 33.—**Ternstrœmiaceæ**, the Tea Family. (*Polypet. Hypog.*) Sepals 5 or 7, concave, coriaceous, deciduous, the innermost often the argest; æstivation imbricated (fig. 265 *c*). Petals 5, 6, or 9, often ombined at the base (fig. 265 *p*). Stamens indefinite, hypogynous; laments free, or united at the base into one or more parcels; anthers ersatile, or adnate, dehiscing longitudinally. Ovary multilocular; tyles 2-7. Fruit either a capsule, 2-7 celled, opening by valves, or oriaceous and indehiscent. Seeds attached to the axis, few and large; lbumen 0, or in very small quantity; embryo straight or bent, or lded back; radicle next the hilum; cotyledons very large, often conining oil.—Trees or shrubs, with alternate coriaceous, exstipulate aves, which are sometimes dotted. They abound in South America, id many occur in India, while others inhabit China and North merica. There are 39 genera, and 154 species enumerated. *Exnples*—Ternstrœmia, Gordonia, Camellia, Thea.

793. The most important plants of this order are those which yield ea. Considerable discussion has taken place regarding the Tea plants; me say that there is only one species; others, two; others, three. ortune visited the black and green tea districts of Canton, Fokien, d Chekiang, and he says that the black and green teas of the norern districts of China are obtained from the same species or variety, t. that cultivated in Britain under the name of *Thea viridis;* while e black and green teas from the neighbourhood of Canton are made m the species or variety cultivated in this country under the name *Thea Bohea*. Some make the Assam plant a different species, and is recognize three, *Thea Cantoniensis* or *Bohea*, *Thea viridis*, and *Thea samica*. The quality of the tea depends much on the season when the ves are picked, the mode in which it is prepared, as well as the district

in which it grows. Green Tea contains more essential oil and tannin than Black Tea. The Green Teas include Twankay, Young Hyson, Hyson, Gunpowder, and Imperial; while the black include Bohea, Congou, Souchong, Oolong, and Pekoe. The teas of certain districts, such as Ankoi, have peculiar characters. In some instances teas are dyed by means of *Isatis indigotica*; in other cases, by Prussian blue, turmeric, and gypsum. Perfume is communicated to teas by means of *Olea fragrans*, *Chloranthus inconspicuus*, and *Aglaia odorata*. There is a bitter principle in tea called *theine*, which may be procured by adding a slight excess of acetate of lead to a decoction of tea, filtering hot, evaporating, and subliming. According to Dr. Stenhouse,

1 lb. of Green Hyson Tea gave 72 grains pure white Theine, and 2 coloured = 74 grains or 1·05 p. c.
8 oz. Black Congou gave 34·5 gr. pure, and 1·5 impure = 36 gr. or 1·02 p. c.
6 oz. of Black Assam Tea yielded 36 gr. or 1·37 p. c.
1 lb. of a cheap Green Tea, called Twankay, gave 69 gr. or 0·98 p. c.

In 1846, the Imports of Tea into the United Kingdom were—

Black, about	43,000,000 lbs.
Green, about	13,000,000 —
Total,	56,000,000 —

In 1856, the total imports were 63,500,000 lbs. An interesting account of the Tea plants, and the manufacture of Tea, will be found in Fortune's "Travels in China," in Ball's "Account of the Cultivation and Manufacture of Tea," Royle's "Illustrations of Himalayan Botany," and his "Productive Resources of India." The genus *Camellia* is prized on account of its showy flowers. There are numerous cultivated varieties of *Camellia japonica*, many of which can endure the climate of Britain when trained on a wall with a southern exposure, or slightly protected. In China, *Camellia Sasanqua*, or Sasanqua tea, is cultivated on account of its flowers, which are said to impart fragrance and flavour to other teas. *Camellia oleifera* yields a valuable oil.

794. Order 34.—**Olacaceæ**, the Olax Family. (*Polypet. Hypog.*) Calyx small, gamosepalous, entire or toothed, often becoming finally large and fleshy; æstivation imbricated. Petals 3-6, hypogynous, free, or adhering in pairs by means of the stamens; æstivation valvate. Stamens hypogynous, some fertile, others sterile; the former 3-10, alternate with the petals, the latter opposite to the petals; filaments compressed; anthers innate, bilocular, with longitudinal dehiscence. Ovary 1-3-4-celled; ovules 1-3, pendulous from a central placenta; style filiform; stigma simple. Fruit fleshy, indehiscent, often surrounded by the enlarged calyx, unilocular, monospermal. Seed anatropal, pendulous; albumen copious, fleshy; embryo small, at the base of the albumen.—Trees or shrubs, with simple, alternate, exsti-

pulate leaves, which are, however, sometimes abortive. They are chiefly tropical or subtropical—being found in the East Indies, New Holland, and Africa. One only is known in the West Indies. A few are from the Cape of Good Hope. Little is known in regard to their properties. *Olax zeylanica* has a fetid wood with a saline taste and is employed in putrid fevers; its leaves are used in a salad. There are 42 genera, and 128 species enumerated. *Examples*—Olax, Opilia, Icacina.

795. Order 35.—**Aurantiaceæ**, the Orange Family. (*Polypet. Hypog.*) Calyx urceolate or campanulate, short, 3-5-toothed, withering. Petals 3-5, broad at the base, sometimes slightly coherent; æstivation imbricated. Stamens equal in number to, or a multiple of, the petals; filaments flattened at the base, distinct or combined into one or more parcels; anthers erect. Thalamus enlarged in the form of a hypogynous disk, to which the petals and stamens are attached. Ovary free, multilocular; style 1; stigma thickish, somewhat divided. Fruit a hesperidium, having a spongy separable rind, and pulpy separable cells (¶ 552). Seeds anatropal, attached to the axis, solitary or several, usually pendulous, having the chalaza and raphe usually well marked; perisperm 0; embryo straight; cotyledons thick and fleshy.—Trees or shrubs, usually conspicuous for their beauty, with alternate, often compound leaves, which are articulated with a usually winged petiole (fig. 185). They abound in the East Indies. *Limonia Laureola* is remarkable as the only plant of this family found on the tops of cold and lofty mountains, where it is for some months of the year covered with snow. There are 23 genera, and nearly 101 species enumerated. *Examples*—Citrus, Limonia, Triphasia.

796. The plants exhibit in every part receptacles of volatile oil. The oil abounds in the leaves and in the rind of the fruit. It is fragrant and bitter. The fruit has a more or less acid pulp, and the wood is generally compact. The Orange, Lemon, Lime, Citron, Shaddock, and Forbidden Fruit, belong to this order. *Citrus vulgaris*, yields the Bitter or Seville Orange, from the flowers of which an essential oil, called Neroli-oil, is procured, in the proportion of an ounce from 550 pounds of flowers. A similar oil is got from the flower of the Sweet Orange, *Citrus Aurantium*. The rind of the Bitter Orange is used in conserves. In the young state, the fruit is sold under the name of Orangettes or Curaçoa oranges. Orange-flower-water, as obtained from the flowers of the Bitter Orange, is employed as an anodyne. The chief kinds of Sweet Orange are the Common Orange, the Chinese or Mandarin Orange, the Maltese, and St. Michael's. The last are the finest imported into Britain, and are distinguished by their smooth, thin rind. A single tree, it is said, will produce 20,000 good oranges. Their fruit is used medicinally,

on account of the pulp, which contains sugar, mucilage, and citric acid. From the rind of the Sweet Orange, an oil, called Oil of Orange, is procured, which differs from Neroli-oil. A similar oil, but of inferior quality, is procured from the rind of the Seville Orange. Many look on the Bitter and Sweet Oranges as produced by varieties of one species. The Bitter Orange-tree is less than that yielding the Sweet Orange; the petioles are more distinctly foliaceous; the flowers have a sweeter fragrance; the rind of the fruit is darker and more bitter; and its pulp more bitter and less saccharine. The Lemon, Lime, and Citron, are distinguished from oranges by their oblong form, their adherent rind, and a protuberance at the apex. *Citrus Limonum* yields the Lemon, the juice of which is antiscorbutic, and is used for cooling drinks and effervescing draughts, while the peel or rind, on account of the oil it contains, is employed as an aromatic and anthelmintic. A single tree will produce 8,000 lemons. *Citrus medica* furnishes the Citron, which is larger than the Lemon, has a thicker and tuberculated rind, and a less acid pulp. The rind and juice may be applied to the same purposes as those of the Lemon. *Citrus Limetta* is the source of the Bergamot and Lime, which are probably merely varieties. The Bergamot is less than the Lemon in size, and is more pyriform, while its colour is golden. The Lime is about half the size of the Lemon; its rind is thin, dense, and of a greenish-yellow colour, and its taste is more bitter. Oil of Bergamot is the volatile oil of the rind, and 100 fruits are said to yield 2½ ounces. *Citrus Decumana* furnishes the Shaddock; *C. paradisi*, the forbidden fruit; *C olivæformis*, the Kumquat; and *C. Pompelmos*, the Pompelmoose fruit. What are called horned oranges and fingered citrons, are produced by a separation or multiplication of the carpels. Sometimes small fruits are enclosed within the large one. *Ægle Marmelos* yields an excellent fruit. From *Feronia elephantum*, a gum, like gum-arabic, is procured.

797. Order 36.—**Hypericaceæ**, the Tutsan or St. John's-wort Family. (*Polypet. Hypog.*) Sepals 4-5, separate or united, persistent, usually with glandular dots, unequal; æstivation imbricated. Petals 4-5, oblique, often with black dots, æstivation contorted. Stamens hypogynous, ∞; generally polyadelphous (fig. 315), very rarely 10, and monadelphous or distinct; filaments filiform; anthers bilocular, with longitudinal dehiscence; carpels 2-5, united round a central or basal placenta; styles the same number as the carpels, usually separate; stigmas capitate or simple. Fruit either fleshy or capsular, multilocular, and multivalvular, rarely unilocular. Seeds usually 00, minute, anatropal, usually exalbuminous; embryo usually straight.—Herbaceous plants, shrubs or trees, with exstipulate entire leaves, which are usually opposite and dotted. Flowers often yellow. They are distributed very generally over all parts of the globe, are found in elevated and low, dry and damp situations. They yield a resinous coloured

juice which has purgative properties, and resembles gamboge. In the European species this yellow juice is in small proportion to the essential oil, and the rest of the vegetable matter; they have been used as tonics and astringents. *Hypericum hircinum* is fetid. A gargle for sore throats is prepared in Brazil from the *Hypericum connatum*. A decoction of the leaves of *Hypericum laxiusculum*, or Allecrim brabo, is reputed in the same country to be a specific against the bite of serpents. Lindley places Parnassia in this order. There are 17 known genera, and about 281 species. *Examples*—Hypericum, Elodea, Vismia, Reaumuria.

798. Order 37.—**Guttiferæ, or Clusiaceæ**, the Gamboge Family. (*Polypet. Hypog.*) Sepals 2-6 or 8, usually persistent, round, frequently unequal and coloured; æstivation imbricated. Petals hypogynous, equal to, or a multiple of, the sepals. Stamens hypogynous, usually 00, rarely definite, free or variously united at the base; filaments unequal in length; anthers adnate, introrse or extrorse, sometimes very small, occasionally unilocular, and sometimes with porous or circumscissile dehiscence. Thalamus forming a fleshy, sometimes 5-lobed disk. Ovary solitary, 1 or many-celled; ovules either solitary and erect or ascending, or numerous and attached to central placentas; style 0 or very short stigmas peltate or radiate. Fruit dry or fleshy, 1 or many-celled, 1 or many-seeded, either with septicidal dehiscence or indehiscent. Seeds definite, anatropal, or orthotropal, in a pulp, apterous and often arillate, with a thin and membranous spermoderm; albumen 0; embryo straight; cotyledons usually cohering.—Trees or shrubs, sometimes parasitical, with exstipulate, opposite, coriaceous, entire leaves, having a strong midrib, and lateral veins running directly to the margin. Flowers articulated with the peduncle, often unisexual by abortion. They are natives of tropical regions, more especially of South America; a few are from Madagascar and the continent of Africa. They generally require situations combining excessive heat and humidity. Authors enumerate 33 genera, including 166 species. *Examples*—Clusia, Garcinia, Cambogia, and Calophyllum.

799. The plants of this order yield a resinous juice, which is acrid, purgative, and has a yellow colour. Gamboge is one of the most important products. There are two kinds of gamboge, one called Siam, and the other Ceylon Gamboge. The latter is the product of *Cambogia gutta* or *Hebradendron cambogioides*, and it is probable that the other, which is the only sort in commerce, and which is known by the names of Pipe, Lump, and Coarse Gamboge, is derived from the same source. Another kind of gamboge, called Coorg or Wynaad Gamboge, seems to be the produce of *Garcinia elliptica*. Gamboge is a powerful irritant, and in large doses acts as a poison, causing inflammation of the mucous membrane. It is employed medicinally, as a drastic and hydragogue cathartic. It is an excellent pigment. The

resin of Tacamahaca is yielded by *Calophyllum Calaba.* An oil is obtained from the seeds of *Calophyllum inophyllum.* *Pentadesma butyracea* is the Butter and Tallow-tree of Sierra Leone, so called on account of the solid oil which is furnished by the fruit. While an acrid resin is the product of most of the plants of the order, there are some parts in which the resin is either absent or elaborated in small quantity. Thus some of them produce fruits which are used as articles of diet. *Garcinia Mangostana* supplies the East Indian Mangosteen, which is said to be one of the finest known fruits; it resembles a middle-sized Orange, and is filled with a sweet and highly-flavoured pulp. *Mammea americana* gives a drupaceous fruit, called Mammee Apple, or Wild Apricot of South America. Its seeds are anthelmintic; its flowers yield by distillation a stomachic spirit called Eau de Créole; and a wine is obtained by fermenting its sap. *Mesua ferrea* yields a hard and durable timber. The *Clusias* are handsome trees, remarkable for the mode in which they send out adventitious roots. The fruit of *Clusia flava*, sometimes called Wild Mango, or Balsam-tree, yields a yellow juice like gamboge.

800. Order 38.—**Marcgraviaceæ**, the Marcgravia Family. (*Polypet. Hypog.*) Sepals 2-7, usually coriaceous and persistent; æstivation imbricated. Corolla hypogynous, of 5 petals, or gamopetalous, calyptriform, entire or torn at the point. Stamens usually 00, very rarely 5, hypogynous; filaments dilated at the base; anthers long, erect, introrse. Ovary single, unilocular; style 1; stigma often capitate. Fruit coriaceous, indehiscent, or dehiscing by valves in a loculicidal manner, the placentas being parietal and forming spurious dissepiments. Seeds indefinite, minute, in a pulp, anatropal, exalbuminous; embryo straight.—Trees and shrubs, with alternate, simple, entire, coriaceous, and exstipulate leaves. Flowers furnished occasionally with bracts, which are folded and united so as to form ascidia. They occur chiefly in the warmer parts of America. Their properties are scarcely known. The stem, root, and leaves of *Marcgravia umbellata*, are regarded in the West Indies as diuretic. There are four genera mentioned, and 26 species. *Examples*—Marcgravia, Norantea.

801. Order 39.—**Hippocrateaceæ**, the Hippocratea Family. (*Polypet. Hypog.*) Sepals 5, very small, united up to the middle, persistent, with an imbricated æstivation. Petals 5, with an imbricated æstivation. Stamens 3, monadelphous; the united filaments forming a tube or a disk-like cup round the ovary; anthers with transverse dehiscence. Ovary free, trilocular; style 1; stigmas 1-3. Fruit consisting either of 3 samaroid carpels, or fleshy and 1-3 celled. Seeds definite, about 4 in each cell, attached to a central placenta, exalbuminous, anatropal, with a straight embryo, and flat somewhat fleshy cotyledons.—Arborescent or climbing shrubs, with opposite, simple, somewhat coriaceous leaves, having small deciduous stipules. They are found principally

in south America; a few are natives of Africa and the East Indies. The fruit of some is eatable. The fruit of *Tontelea* (*Salacia*) *pyriformis*, a native of Sierra Leone, is about the size of a Bergamot Pear; its flavour is rich and sweet. The nuts of *Hippocratea comosa* are oily and sweet; it is called in the French West Indian Islands, Amandier du Bois. Authors mention 7 genera, comprehending 91 species. *Examples*—Hippocratea, Salacia.

802. Order 40. **Erythroxylaceæ**, the Erythroxylon Family. (*Polypet. Hypog.*) Sepals 5, united at the base, persistent; æstivation imbricated. Petals 5, hypogynous, broad and with a small scale at the base, slightly contorted in æstivation. Stamens 10, monadelphous; anthers erect, bilocular, with longitudinal dehiscence. Ovary 3-celled, two of which are sometimes abortive; styles 3, distinct or united; stigmas 3; ovule single, pendulous. Fruit a 1-seeded drupe. Seed angular, anatropal; embryo in the axis of firm albumen, rarely exalbuminous; cotyledons linear, flat, and leafy.—Shrubs or trees with alternate stipulate leaves. Flowers arising from numerous, imbricated, scale-like bracts. Found chiefly in the West Indies and South America. The plants of the order have tonic, purgative, and narcotic qualities. The leaves of *Erythroxylon Coca* are used by the miners of Peru as a stimulant like opium. They are chewed with a small mixture of finely powdered chalk. The wood of some is of a bright red colour, and yields a dye. There are 2 or 3 known genera, and about 80 species. *Examples*—Erythroxylon, Sethia.

803. Order 41.—**Malpighiaceæ**, the Malpighia Family. (*Polypet. Hypog.*) Sepals 5, slightly united, persistent, often glandular at the base; æstivation imbricated. Petals 5, unguiculate, with convolute æstivation. Stamens usually 10, often monadelphous; anthers roundish, with a projecting process from the connective (fig. 342). Ovary formed by 3 (rarely 2 or 4) carpels, more or less combined; ovules solitary, with a long pendulous cord; styles 3, distinct or united. Fruit dry or fleshy, sometimes winged (fig. 466). Seeds solitary, orthotropal, suspended, exalbuminous; embryo straight or curved in various ways; cotyledons foliaceous or thickish (fig. 506).—Trees or shrubs, sometimes climbing, with simple, opposite, or very rarely alternate, stipulate leaves, without dots. Hairs, when present, peltate. Flowers either perfect or unisexual. They are inhabitants of tropical countries chiefly, and a great number of them are found in South America. Authors notice 45 genera, including 569 species. *Examples*—Malpighia, Banisteria, Hiptage, Hiræa, Gaudichaudia.

804. Some of the woody plants of this order exhibit an anomalous formation of the stem, from the absence of annular rings and medullary rays, and the peculiar mode in which the bark is produced. This is shown in figs. 105, 108, and 109. Many of the plants are astringent. Some have stinging hairs (fig. 84). The fruit of *Mal-*

pighia glabra is called Barbadoes Cherry, and is used as an article of dessert. *Nitraria* is a genus doubtfully referred to this order. *N. tridentata*, found in the desert of Soussa, near Tunis, is said by some to be the true Lotus-tree of the ancient Lotophagi.

805. Order 42.—**Aceraceæ**, the Maple Family. (*Polypet. Hypog.*) Calyx divided into 5, rarely into 4 or 9 parts, with an imbricated æstivation. Petals equal in number to the lobes of the calyx, with which they alternate, rarely wanting. Stamens generally 8, inserted on a hypogynous disk. Ovary free, 2-lobed, 2-celled; ovules in pairs; amphitropal, pendulous; style 1; stigmas 2. Fruit, a samara (fig. 465), composed of two winged carpels, each 1-celled with 1-2 seeds. Seeds erect, exalbuminous; embryo curved, with foliaceous cotyledons, and the radicle next the hilum.—Trees with opposite, simple, lobed or palmate, exstipulate leaves. Flowers often polygamous. They are confined chiefly to the temperate parts of Europe, Asia, and North America. They yield a saccharine sap, from which sugar is sometimes manufactured. It is said that their juices become acrid as the season advances. The bark is astringent, and yields reddish-brown and yellow-coloured dyes. *Acer saccharinum* is the Sugar Maple of America. *Acer Pseudo-platanus*, the Sycamore or Great Maple (the Plane-tree of Scotland), acts well as a shelter in exposed places, as near the sea. Its sap is slightly saccharine. Its wood is used in machinery and for charcoal. The leaves are often covered with black spots, caused by the attack of a fungus, Xyloma or Rytisma acerinum. There are 3 known genera, and 60 species. *Examples*—Acer, Negundo, Dobinea.

806. Order 43.—**Sapindaceæ**, the Soapwort Family. (*Polypet. Hypog.*) Sepals 4-5, distinct or cohering at the base; æstivation imbricated. Petals 4-5, occasionally absent, hypogynous, sometimes naked, sometimes with a glandular or scaly appendage inside; æstivation imbricated. Stamens usually 8-10, sometimes 5-6-7, very rarely 20; filaments free, or combined just at the base; anthers introrse. Thalamus forming a fleshy or glandular disc, into which the stamens are often inserted. Ovary trilocular, rarely bi- or quadri-locular; ovules anatropal, definite; style either undivided or 2-3 cleft. Fruit either fleshy and indehiscent, or samaroid, or capsular, and 2-3 valved. Seeds solitary, often arillate, exalbuminous; embryo straight, curved, or spiral; cotyledons incumbent; radicle next the hilum.—Trees or shrubs, sometimes climbing herbaceous plants, with alternate, sometimes opposite, compound (fig. 176), rarely simple leaves, often marked with lines or pellucid dots. They are natives principally of South America and India. Africa contains many of them; they are wanting in the cold regions of the north. None are found wild in Europe. In this order are included the Hippocastaneæ or Horse-chestnuts, which are distinguished by their opposite leaves, and their two ovules in each cell, one ascending, the other suspended (fig. 428). Authors give 77

genera, including 440 species. *Examples*—Sapindus, Paullinia, Nephelium, Æsculus, Pavia, Dodonæa, Meliosma.

807. In this order are included many plants which yield edible fruits, and others which are poisonous. A saponaceous principle exists in certain species. The fruit of *Sapindus Saponaria*, under the name of Soap-berries, is used as a substitute for soap in the West Indies. The Longan and Litchi are excellent Chinese fruits, the produce of *Nephelium Longan* and *N. Litchi*. The kernel of the Longan powdered, is sometimes made into paper. *Blighia* or *Cupania sapida* yields the Akee fruit, the succulent arillus of which is used as food. Many of the *Paullinias* are poisonous. From the seeds of *Paullinia sorbilis*, however, the Guarana bread is prepared in Brazil. The seeds, after being dried and deprived of their white aril, are pounded and kneaded into a dough, which is afterwards made up into cakes or balls. This Guarana contains a bitter crystalline matter called Guaranine, identical with Caffeine. The bark of *Æsculus Hippocastanum*, Horse-chestnut, has been recommended as a febrifuge, and its seeds have been used as a substitute for coffee. The fruit and leaves of *Æsculus ohiotensis*, the Buck-eye or American Horse-chestnut, are said to be poisonous. *Paullinia pinnata*, and some other Sapindaceæ of Brazil, exhibit anomalous exogenous stems (fig. 106). *Ophiocaryon paradoxum*, is the Snake-nut-tree of Demerara, and is so called on account of the embryo, resembling a coiled-up snake.

808. Order 44.—**Rhizobolaceæ**, the Souari-nut Family. (*Polypet. Hypog.*) Sepals 5, more or less combined; æstivation imbricated. Petals usually 5, unequal, thickish. Stamens indefinite, slightly monadelphous, arising from a hypogynous disk, in a double row, of which the inner is often abortive; anthers roundish, with longitudinal dehiscence. Ovary 4-5 celled; ovules solitary, semi-anatropal; styles as many as the cells of the ovary; stigmas simple. Fruit formed of several indehiscent, 1-celled, 1-seeded nuts, with a thick double endocarp. Seed reniform, exalbuminous, with the funiculus dilated into a spongy excresence; embryo with a very large radicle, which constitutes nearly the whole of the kernel: cotyledons small, lying in a furrow of the radicle (fig. 503).—Trees with opposite, palmately compound, coriaceous, exstipulate leaves. They grow in the warm forests of South America. Some of them furnish oil, others yield edible nuts. Souari nuts are the produce of *Caryocar butyrosum* (*Pekea butyrosa*). Lindley notices 2 genera, and 8 species. *Examples*—Caryocar, Anthodiscus.

809. Order 45.—**Meliaceæ**, the Melia Family. (*Polypet. Hypog.*) Sepals 4-5, more or less united, with an imbricated æstivation. Petals 4-5, hypogynous, sometimes cohering at the base, with a valvate or imbricated æstivation. Stamens equal in number to the petals, or 2, 3, or 4 times as many; filaments combined in a long tube; anthers

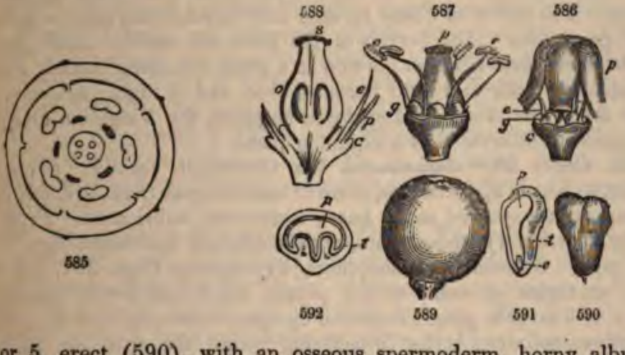
sessile within the orifice of the tube. Disk often large and cup-shaped. Ovary single, multilocular, the cells often equal in number to the petals; ovules usually anatropal, 1-2 in each cell; style 1; stigmas distinct or united. Fruit baccate, drupaceous or capsular, multilocular, or by abortion unilocular, when valves are present opening by loculicidal dehiscence. Seeds not winged; albumen usually absent; embryo straight, with leafy cotyledons.—Trees or shrubs with alternate (occasionally opposite), exstipulate, simple, or pinnate leaves. They are chiefly found in the tropical parts of America and Asia. Under this order, some include Humiriaceæ, which are distinguished by a prolonged fleshy connective (fig. 341), albuminous seeds, and a slender embryo. Arnott includes Cedrelaceæ also under this order. There are about 43 known genera, and upwards of 180 species. *Examples*—Melia, Trichilia, Humirium, Canella.

810. The plants of this order possess bitter, tonic, and astringent qualities. *Melia Azedarachta* is used in India as a febrifuge, and its fruit yields an oil which is employed for domestic purposes, and as an antispasmodic. The root of *Melia Azedarach* is bitter and nauseous, and is used in North America as an anthelmintic. Oils are procured also from species of *Trichilia* and *Carapa* (fig. 507). A warm pleasant smelling oil is prepared from the fruit of *Trichilia speciosa*, which in India is considered as a valuable external remedy in chronic rheumatism and paralytic affections. The bark of *Carapa guineensis* has reputation as an anthelmintic. The fruit called in the Indian Archipelago, Langsat, is the produce of a species of *Lansium*. A fragrant balsam, called Balsam of Umiri, is got from the trunk of *Humirium floribundum*. *Canella alba*, the plant which furnishes Canella bark, has been referred to this order, but great doubts exist as to the propriety of doing so. Lindley makes it provisionally a separate order, Canellaceæ, which he places near Pittosporaceæ. Canella bark is hot and aromatic, and is used as a spice, and medicinally as a stimulant tonic. It was formerly confounded with Winter's bark, and the plant was called by Linnæus, Winterania Canella, or spurious Winter's bark.

811. Order 46.—**Cedrelaceæ**, the Mahogany Family. (*Polypet. Hypog.*) Calyx 4-5-cleft, with imbricated æstivation. Petals 4-5, with imbricated æstivation. Stamens 8-10, united below into a tube, sometimes distinct, inserted into a hypogynous annular disk; anthers bilocular, acuminated, with longitudinal dehiscence. Ovary usually 4 or 5-celled; ovules anatropal, pendulous; style simple; stigma peltate. Fruit a capsule opening septifragally (figs. 450, 451). Seeds winged; albumen thin or 0; embryo straight, erect; cotyledons fleshy.—Trees with alternate, pinnate, exstipulate leaves. They are found in the tropical parts of America and Asia. Authors enumerate 11 genera, including 27 species. *Examples*—Cedrela, Swietenia.

812. The plants of this order are bitter, and have an aromatic fragrance. *Swietenia Mahagoni* supplies the well-known mahogany wood. Its bark, as well as that of *Soymida febrifuga*, and of *Cedrela febrifuga*, are used for the cure of intermittents. *Chloroxylon Swietenia* produces satin wood, and also yields a kind of wood-oil.

813. Order 47.—**Ampelideæ** or **Vitaceæ**, the Vine Family. (*Polypet. Hypog.*) Calyx small, nearly entire (fig. 586 *c*). Petals 4-5, sometimes cohering above (fig. 586 *p*), inserted outside an annular hypogynous disk (figs. 586, 587 *g*); æstivation valvate. Stamens 4-5, opposite to the petals (figs. 586, 587 *e*), inserted on the disk; filaments free, or united at the base; anthers ovate, versatile (fig. 587). Ovary 2-6-celled; ovules erect, anatropal (fig. 588 *o*); style 1, very short; stigma simple (588 *s*). Fruit pulpy and globular, not united to the calyx (fig. 589), sometimes 1-celled by abortion. Seeds 1 to 4 or 5, erect (590), with an osseous spermoderm, horny albumen (figs. 591, 592 *p*), and an erect embryo (fig. 591 *e*).—Climbing shrubs, having the lower leaves opposite, the upper ones alternate (fig. 221). Flowers in racemes, which are often opposite the leaves; floral peduncles sometimes becoming cirrhose. They inhabit the



Figs. 585-592.—Organs of fructification of Vitis vinifera, to illustrate the natural order Vitaceæ or Ampelideæ.

Fig. 585.—Diagram of the flower, showing 5 sepals, 5 petals, 5 stamens opposite the petals on account of the non-development of one staminal row, a disk, and the ovary.

Fig. 586.—Flower showing the petals, *p*, detached at the base, and remaining united above in a calyptra-like manner. *c*, Calyx. *g*, Glands, forming a disk. *e*, Stamens, the filaments of which only are seen.

Fig. 587.—Flower after the petals have fallen. *g*, Glands of the disk. *e*, Stamens, with versatile anthers. *p*, Pistil.

Fig. 588.—Vertical section of the flower. *c*, Calyx. *p*, Petals. *e*, Filaments. *o*, Ovary, with 2 cells and their erect anatropal ovules. *s*, Stigma.

Fig. 589.—Globular pulpy fruit, uva, or grape, differing from a berry, in the calyx not forming part of the pericarp. It is by some called nuculanium.

Fig. 590.—The seed of the grape, with its osseous spermoderm enclosing a hard perisperm.

Fig. 591.—The seed cut vertically. *t*, The integument or spermoderm. *p*, Perisperm, or albumen, which is horny. *e*, Erect embryo, with lanceolate cotyledons.

Fig. 592.—Horizontal section of the seed of the grape, about the middle. *t*, Integument or spermoderm. *p*, Perisperm or albumen.

milder as well as the hotter parts of both hemispheres, and abound in the West Indies. There are 8 genera, and 266 species. *Examples*—Vitis, Cissus, Leea.

814. The plants of this order have generally acid leaves, and their fruit, when ripe, is saccharine. *Vitis vinifera*, the Grape Vine, belongs to this order. It is said to be a native of the shores of the Caspian, whence it was imported into Europe. The unripe fruit contains a harsh acid juice, called verjuice. It contains free citric, malic, and tartaric acids, along with bitartrate of potass. As grapes ripen, sugar, called Grape-sugar, is formed at the expense of the acids (¶ 304). The vessels of the Vine are large (fig. 61), and the sap passes through them with great force and rapidity. When cut in spring the plant bleeds freely. The leaves of the vine, on account of their astringency, have been used in diarrhœa. In France its sap is a popular remedy for chronic ophthalmia. *Vitis vulpina* yields the Fox-grapes of Rhode Island. The leaves of *Cissus cordata* and *C. setosa* are said to possess acrid properties. The berries of the latter are acrid. Both leaves and fruit of *Cissus tinctoria* abound in a green colouring matter, which on exposure to air and light becomes blue, and is highly esteemed as a dye for cotton fabrics. *Ampelopsis virginica*, the Virginian creeper, is commonly cultivated as a climbing plant.

815. Order 48.—**Geraniaceæ,** the Cranesbill Family. (*Polypet. Hypog.*) Sepals 5, persistent, more or less unequal (figs. 307, 347 *cc*), one sometimes spurred at the base; æstivation imbricated. Petals 5 (or by abortion 4), unguiculate, with contorted æstivation (figs. 307, 347, *p p*). Stamens monadelphous, hypogynous (figs. 307, 347 *e*), twice or thrice as many as the petals, some occasionally abortive. Ovary of 5 carpels, placed round an elongated axis (fig. 307 *t*); ovules pendulous, solitary; styles 5, cohering round the axis (fig. 307 *o*). Fruit formed of 5 one-seeded coccoons, terminated each by an indurated style, which curls upwards, carrying the coccus or pericarp with it (fig. 455). Seeds exalbuminous, solitary, with a curved folded embryo, and leafy, convolute, and plaited cotyledons (fig. 511.)—Herbs or shrubs with simple, stipulate leaves, which are either opposite, or alternate with peduncles opposite to them. They are distributed over various parts of the world. The species of Pelargoniun abound at the Cape of Good Hope. Authors mention 7 genera, including, after separating hybrids, about 520 species. *Examples*—Geranium, Pelargonium.

816. The name Cranesbill is derived from the long beak-like prolongation of the axis, or what is called the carpophore (¶ 437). The plants of this order are astringent and aromatic. The root of *Geranium maculatum*, receives the name Alum root, in consequence of being a very powerful astringent. The tuberous or moniliform roots of some, such as *Pelargonium triste* (fig. 123), are eatable

The species of Pelargonium are remarkable for the beauty of their flowers. By the art of the gardener, and by hybridization, many fine varieties of Pelargonium have been produced.

817. Order 49.—**Linaceæ,** the Flax Family. (*Polypet. Hypog.*) Sepals 3, 4, or 5, persistent, with an imbricated æstivation. Petals 3, 4, or 5, fugitive, unguiculate, hypogynous, with a twisted æstivation. Stamens equal to the petals and alternate with them (with intermediate teeth or abortive stamens), arising from a hypogynous annular disk; anthers ovate, erect. Ovary with as many cells and styles as sepals, seldom fewer; stigmas capitate; ovules anatropal, pendulous. Fruit a multilocular capsule, pointed generally with the indurated base of the styles; each loculament or cell more or less completely divided by a spurious dissepiment, arising from the dorsal suture, and opening by two valves at the apex. Seeds solitary in each spurious cell, compressed, pendulous; albumen usually in small quantity, sometimes 0; embryo straight; cotyledons flat; radicle next the hilum.—Annual and perennial plants, with exstipulate, simple, entire leaves, which are usually alternate. They are scattered over the globe, but are said to be most abundant in Europe, and in the north of Africa. By some authors the order is associated with Geraniaceæ, from which it differs in its unbeaked fruit and exstipulate leaves, as well as the absence of joints in the stem. There are 4 genera mentioned by Lindley, comprising 90 species. *Examples*—Linum, Radiola.

818. The plants yield mucilage and fibre. Flax, which consists of woody fibre (fig. 44), is procured from the inner bark of the stalk of *Linum usitatissimum*, by the process of steeping and stripping off the bark. Linen and cambric are prepared from it. The flax plant is supposed to have been originally a native of Egypt, and mummy cloth has been shown to be formed of linen. The integument of the seeds is mucilaginous, and an infusion of them in boiling water is used as a demulcent and diuretic. The cotyledons of the seeds are oleaginous, and by expression yield Linseed oil, which has the property of drying and hardening into an elastic varnish, on exposure to the air. It is used medicinally for burns mixed with lime water. After expressing the oil a cake remains, called oil-cake, which is used for fattening cattle. The powdered cake receives the name of Linseed meal, and is commonly used for poultices. Another species of *Linum*, called *L. catharticum*, has purgative properties, which seem to depend on the presence of an acrid bitter matter, called Linin. *Linum selaginoides* is considered in Peru bitter and aperient.

819. Order 50.—**Balsaminaceæ,** the Balsam Family. (*Polypet. Hypog.*) Sepals 5, irregular, deciduous, the two inner and upper connate, coloured, the lower (odd) sepal spurred (fig. 541); æstivation imbricated. Petals alternate with the sepals, usually 4, in conse-

quence of 1 being abortive, often more or less irregularly æstivation convolute. Stamens 5. Ovary 5-celled; ovules numerous, stigma sessile, more or less 5-lobed. Fruit a capsule, opening septifragally, by 5 elastic valves. Seeds numerous; suspended, exalbuminous, with a straight emb radicle next the hilum. Succulent herbaceous plants witl juice, having simple, opposite, or alternate, exstipulate lea axillary irregular flowers. They inhabit chiefly the East In are remarkable for the force with which the seed-vessels op ripe. The valves give way on account of the osmose whicl in the cells, and they then curl up in a peculiar manner (¶ They have usually showy flowers, but their properties are unin Lindley mentions 2 genera, including 113 species. *Examp* patiens, Hydrocera.

820. Order 51.—**Oxalidaceæ,** the Wood-sorrel Family. *Hypog.*) Sepals 5, equal, sometimes cohering slightly at t persistent, imbricate in æstivation. Petals 5, equal, ung hypogynous, with a twisted æstivation. Stamens 10, more monadelphous, in 2 rows; those opposite the petals being lon those in the outer row; anthers erect, bilocular. Ovary usua quelocular; styles filiform, distinct; stigmas capitate or sligh Fruit capsular, membranous or fleshy, usually 5-celled, an dehiscent 5-10 valved. Seeds few, anatropal, albuminous, to a central placenta, sometimes with a peculiar elastic inte embryo straight, as long as the fleshy albumen, with a long ra leafy cotyledons.—Herbs, undershrubs, or trees, with alterna opposite compound (occasionally simple) leaves, which are without stipules. They are found in the hot as well as the t parts of the world, and are abundant in North America the Cape of Good Hope. The shrubby species are confine hotter parts of the world. In some cases phyllodia, or petioles, occupy the place of leaves. There are about 1 genera, and upwards of 336 species. *Examples*—Oxalis, A Hugonia.

821. They are often acid in their properties. Some of th esculent roots. *Oxalis Acetosella*, common Wood-sorrel, re name from its acid taste. It contains binoxalate of potash, sometimes called the salt of sorrel, and at other times the ess of lemons. The plant has been used as a refrigerant and antis Its leaves are trifoliate, and some have considered it to be Shamrock, in consequence of being in flower about the peri year when St. Patrick's day occurs. Some of the oxalises, as *tiva*, have sensitive leaves, and experiments have been made to their closing and opening by Morren (¶ 660). *Oxalis esculenta*, and *Deppei*, yield tubers, which have been used as

tute for potatoes. The acid fruit of *Averrhoa Bilimbi* and *Carambola* is used in the East Indies as food.

822. Order 52.—**Tropæolaceæ,** the Indian Cress Family. (*Polypet. Hypog.*) Sepals usually 5, the upper spurred (fig. 275); æstivation slightly imbricate. Petals often 5, hypogynous, more or less unequal, sometimes abortive (fig. 542); æstivation convolute. Stamens 8 or 10, seldom fewer, free, almost perigynous; anthers bilocular, innate. Ovary triquetrous, composed of 3-5 carpels, with a single style, and 3-5 acute stigmas; ovules solitary, often pendulous. Fruit indehiscent, usually composed of 3 pieces. Seeds exalbuminous, with a large embryo, which has thick, often united, cotyledons, and a radicle next the hilum.—Herbaceous trailing or twining plants, having a delicate texture, with alternate exstipulate leaves, and axillary, often gay, flowers. They are natives of the temperate parts of America, and are extensively cultivated on account of their showy yellow, orange, scarlet, and occasionally blue flowers. They have more or less pungency in their fruit, which is used as a cress. The unripe fruit of *Tropæolum majus*, common Indian Cress, has been pickled and used as capers. Their roots are sometimes eaten. Lindley includes Limnantheæ in this order, and enumerates 6 genera, including 44 species. *Example*—Tropæolum.

823. Order 53.—**Pittosporaceæ,** the Pittosporum Family. (*Polypet. Hypog.*) Sepals 4 or 5, deciduous, distinct or partially united; æstivation imbricated. Petals 4 or 5, sometimes slightly cohering, with imbricated æstivation. Stamens 5, distinct, alternate with the petals. Ovary single, 2-5 celled; style 1; stigmas 2-5, equal in number to the placentas. Fruit capsular or berried, with many-seeded cells, which are sometimes incomplete; dehiscence loculicidal. Seeds often enveloped in a glutinous or resinous pulp, anatropal, with a minute embryo lying in fleshy albumen; radicle long; cotyledons very short. —Trees or shrubs, with simple, alternate, exstipulate leaves and flowers occasionally polygamous. They are found chiefly in Australasia. Many of them are resinous, and, in some instances, the berries are eaten Authors mention 13 genera, including 81 species. *Examples*—Pittosporum, Billardiera, Sollya.

824. Order 54.—**Brexiaceæ,** the Brexia Family. (*Polypet. Hypog.*) Calyx small, persistent, of 5 coherent sepals, with an imbricated æstivation Petals 5, with twisted æstivation. Stamens 5, alternate with the petals, arising from a narrow cup or disk, which is toothed between each stamen; anthers bilocular, erect, opening longitudinally and introrsely. Ovary 5-celled; ovules numerous, in two rows; placentas central; style 1; stigma simple. Fruit drupaceous, 5-celled, many-seeded. Seeds having two distinct coverings, anatropal; embryo straight; radicle cylindrical; cotyledons ovate, obtuse.—Trees with coriaceous, alternate leaves, having small deciduous stipules. They exist

principally in Madagascar. Lindley associates some perigynous genera with Brexia, and places the order near Saxifragaceæ. There are 6 genera, including 8 species. *Example*—Brexia.

825. Order 55.—**Zygophyllaceæ,** the Guaiacum Family. (*Polypet. Hypog.*) Calyx 4-5 parted, with convolute æstivation. Petals alternate with the calycine segments, with imbricated æstivation. Stamens twice as many as the petals; filaments dilated at the base, usually arising from scales (fig. 313). Ovary simple, 4-5 celled; divisions occasionally formed by spurious dissepiments (figs. 438, 439). Ovules 2 or more in each cell, usually pendulous; style simple, 4-5 furrowed; stigma simple, or 4-5-lobed. Fruit capsular or rarely fleshy, with 4-5 angles or wings, 4-5-valved, either opening by loculicidal dehiscence, or indehiscent. Seeds few, usually with whitish albumen, sometimes exalbuminous; embryo green, with foliaceous cotyledons, and a superior radicle.—Herbs, shrubs, or trees, with opposite, stipulate, usually compound leaves, which are not dotted, and hermaphrodite flowers. They occur in various parts of the world, chiefly in warm extra-tropical regions, as in the south of Europe, America, Africa, and India. The order has been divided into two sections:—1. Zygophylleæ, having albuminous seeds. 2. Tribuleæ, having exalbuminous seeds. Authors mention 17 genera, comprising 136 species. *Examples*—Zygophyllum, Guaiacum, Tribulus.

826. Some of the plants abound in a stimulant resin, which pervades the wood and bark; others are bitter and acrid. The medicinal species are used as sudorifics. *Zygophyllum Fabago* is called the Bean-caper, on account of its flowers being used as a substitute for capers. The plant is said to act as a vermifuge. *Guaiacum officinale* is a beautiful West Indian tree, the wood of which, commonly called lignum-vitæ, is prized for its hardness. The alburnum is of a grayish-yellow colour, while the duramen is greenish-black. The fibres of the wood are remarkable for their direction, being cross-grained, in consequence of one layer crossing another diagonally. It yields a resinous matter known as the resin of Guaiac, or Gum-guaiac. This resin exudes spontaneously, or it may be procured by incisions, or by the application of heat. A solution of the resin in alcohol, when applied to the fresh cut surface of a potato, gives rise to a blue colour. Both the wood and the resin are used medicinally on account of their stimulant diaphoretic properties. In decoction and tincture they are administered in cutaneous and syphilitic diseases. *Guaiacum sanctum* from Mexico has similar properties, and is sometimes used medicinally on the continent.

827. Order 56.—**Rutaceæ,** the Rue Family. (*Polypet. Hypog.*) See figs. 532, 533. Calyx having 4-5 segments, with an imbricated æstivation. Petals alternate with the divisions of the calyx, distinct, or cohering below into a spurious gamopetalous corolla, rarely want-

ing; æstivation either contorted or valvate. Stamens equal in number to the petals, or twice or thrice as many (rarely fewer by abortion or non-development) (fig. 534), usually hypogynous, but in some instances perigynous. Between the stamens and ovary there is a more or less complete cup-shaped disk, which is either free or united to the calyx. Ovary sessile or supported on a gynophore (fig. 382), its carpels equal to the petals in number or fewer; ovules 2, rarely 4 or fewer in each carpel; styles adherent above (fig. 382); stigma simple or dilated. Fruit capsular, its parts either combined completely or partially; seeds solitary or in pairs, albuminous or exalbuminous; embryo with a superior radicle.—Trees or shrubs, with exstipulate, opposite, or alternate leaves, usually covered with pellucid resinous dots (figs. 87, 89), and hermaphrodite flowers. The order has been subdivided into two suborders:—1. Ruteæ, with albuminous seeds, and the fruit with sarcocarp and endocarp combined. 2. Diosmeæ, with exalbuminous seeds, and a 2-valved endocarp, which dehisces at the base, and when the fruit is ripe separates from a 2-valved sarcocarp. Ruteæ are found chiefly in the southern part of the temperate zone, as in the south of Europe, while Diosmeæ abound at the Cape of Good Hope, and in New Holland. Authors mention 57 genera, and 430 species. *Examples*—Ruta, Dictamnus, Diosma, Barosma, Correa, Boronia.

828. The plants are remarkable for their peculiar odour, which is very powerful and penetrating. Many have antispasmodic properties, while others are bitter, and act as febrifuges and tonics. The leaves and unripe fruit of *Ruta graveolens*, common or garden Rue, are used in medicine as stimulants, antispasmodics, anthelmintics, and emmenagogues. They emit when bruised a strong and peculiar oppressive odour, and have a bitter and acrid taste. By distillation with water, they yield a yellow acrid volatile oil, which is their active constituent. The leaves of various species of *Barosma*, especially *B. crenata* or *crenulata*, and *serratifolia*, are used in medicine under the name of Bucku or Buchu. They contain a yellowish volatile oil, having a powerful odour, and they have been used as stimulants and antispasmodics. They are prescribed in cases of irritation and catarrh of the bladder in the form of infusion and tincture. *Galipea officinalis*, a plant found in Columbian Guiana, supplies the Angustura bark, which is used as a tonic and febrifuge. It is probable that *Galipea Cusparia*, sometimes called *Bonplandia trifoliata*, also furnishes a variety of Angustura bark. On the continent, Angustura bark is sometimes adulterated with the poisonous bark of Strychnos Nux vomica. Some of the species of *Dictamnus*, such as *D. Fraxinella*, False Dittany, abound in volatile oil to such a degree that the atmosphere around them becomes inflammable in hot, dry, and calm weather. The *Correas* are remarkable for their gamopetalous corolla. The leaves of some of the species have been used for tea in New Holland.

829. Order 57.—**Xanthoxylaceæ** or **Zanthoxylaceæ**, the Xanthoxylon Family. (*Polypet Hypog.*) Flowers unisexual. Calyx in 3, 4, or 5 segments, with imbricated æstivation. Petals the same number, rarely 0, usually larger than the calyx; æstivation imbricated or convolute. Stamens as many or twice as many as the petals, not developed in the female flowers. Ovary consisting of as many carpels as there are petals (sometimes fewer), the carpels being either completely or partially united (fig. 380); ovules 2, rarely 4, in each carpel; styles more or less combined (fig. 380 *s*). Fruit baccate or membranous, sometimes of 2-5 cells, sometimes of several drupes, or 2-valved capsules, of which the fleshy sarcocarp is partly separable from the endocarp. Seeds solitary or in pairs, pendulous; embryo lying within fleshy albumen; radicle superior; cotyledons ovate, flat.—Trees or shrubs, with exstipulate, alternate, or opposite leaves, having pellucid dots. They exist chiefly in the tropical parts of America. Authors enumerate 21 genera, including 120 species. *Examples*—Xanthoxylon, Toddalia, Ptelea.

830. The plants yield a volatile oil, which is aromatic and pungent. Some are diaphoretic in their properties, others are febrifugal and tonic. The pungency of species of *Xanthoxylon* has caused them sometimes to be denominated peppers. *Xanthoxylon fraxineum*, or prickly ash, acts as a sialagogue. *X. caribæum* has a bitter and febrifugal bark. The bitter principle secreted by many of the plants of this order is called Xanthopicrine.

831. Order 58.—**Simarubaceæ**, the Quassia and Simaruba Family. (*Polypet. Hypog.*) Flowers usually hermaphrodite. Calyx in 4 or 5 divisions; æstivation imbricated. Petals 4 or 5, spreading or connivent into a kind of tube; æstivation twisted. Stamens twice as many as the petals; filaments arising from scales. Ovary 4-5-lobed, 4-5-celled, supported on a gynophore; ovules solitary; style simple; stigma 4-5-lobed. Fruit indehiscent, consisting of 4 or 5 drupes arranged round a common receptacle. Seeds anatropal, pendulous; embryo exalbuminous.—Trees or shrubs, with exstipulate, alternate, usually compound leaves without dots. They are found in the tropical parts of America, Asia, and Africa. Authors give 12 genera, and 89 species. *Examples*—Simaruba, Quassia, Picræna.

832. All the plants of the order are intensely bitter. Quassia wood was originally the product of *Quassia amara*, a tall shrub, never above 15 feet in height, inhabiting Surinam, Guiana, and Colombia. It is a very ornamental plant, and has remarkable pinnate leaves, with winged petioles. In their early state, the leaves seem to be simple, but in the progress of growth two or more contractions take place, at each of which two leaflets appear, the pairs being separated by a winged midrib,—a continuation of the petiole. This Surinam Quassia does not appear to be exported now, and it is not met with in English

trade. A thriving specimen was recently sent to the Edinburgh Botanic Garden by Professor Syme. The Quassia of the shops is the wood of *Simaruba* or *Picræna excelsa*, a very large forest tree, attaining a height of nearly 100 feet, growing in Jamaica and other West Indian islands, where it is called Bitter Ash, and Bitter Wood. Quassia is used medicinally, in the form of infusion and tincture as a tonic and anthelmintic. It acts as a narcotic poison on flies and other insects. Although prohibited by law, it is frequently employed by brewers as a substitute for hops. The bitterness of Quassia is said to be owing to a crystalline principle called Quassin. The bark of the root of *Simaruba amara* or *officinalis*, a tree found in Cayenne and in the West Indies, is used as a bitter tonic and astringent, more especially in the advanced stages of diarrhœa and dysentery. *Brucea antidysenterica* was at one time erroneously supposed to furnish false Angustura bark. It has properties similar to those of Quassia. Malombo bark is probably yielded by a species of Quassia.

833. Order 59.—**Ochnaceæ**, the Ochna Family. (*Polypet. Hypog.*) Sepals 5, persistent, imbricated in æstivation. Petals equal to, or twice as many as the sepals, deciduous, spreading, imbricated in æstivation. Stamens 5, opposite the sepals, or 10, or indefinite; filaments persistent, attached to a hypogynous disk; anthers bilocular, innate, opening by pores, or longitudinally. Carpels as many as the petals, seated on an enlarged gynobase (thecaphore); ovule erect or pendulous, styles united into one. Fruit gynobasic, consisting of several succulent, indehiscent, monospermous carpels. Seeds anatropal, usually exalbuminous; embryo straight; radicle short; cotyledons thick.—Undershrubs or trees, with alternate, simple, stipulate leaves, and pedicels articulated in the middle. They grow in tropical countries, and are remarkable for the large succulent prolongation of the receptacle to which the carpels are attached. They are generally bitter, and some of them are used as tonics. Lindley enumerates 6 genera, comprehending 86 species. *Examples*—Ochna, Gomphia, Castela.

834. Order 60.—**Coriariaceæ**, the Coriaria Family. (*Polypet. Hypog.*) Flowers unisexual. Calyx campanulate, 5-parted; æstivation imbricate. Petals alternate with the calycine segments, very small, fleshy, with a keel on the internal surface. Stamens 10 (fig. 537); filaments filiform, distinct; anthers dithecal, oblong. Ovary composed usually of 5 carpels, attached to a thickened receptacle or gynobase, 5-celled; ovules solitary, pendulous; style 0; stigmas 5, long and glandular. Fruit, consisting of 5, monospermous, indehiscent crustaceous carpels, enclosed by the enlarged petals. Seeds pendulous, anatropal, exalbuminous; embryo nearly straight; cotyledons fleshy; radicle short and blunt.—Shrubs with opposite square branches, opposite, simple, ribbed leaves, and scaly buds. They are found in small numbers in the south of Europe, South America, India, and New

Zealand. Some of them are poisonous. The leaves of *Coriaria myrtifolia* have been employed to adulterate Alexandrian Senna on the continent. The leaves are known from those of true Senna by being 3-ribbed. The leaves are used for dyeing black, and an infusion of them gives a dark-blue with sulphate of iron. Genus 1; species 8. *Example*—Coriaria.

Subclass II.—CALYCIFLORÆ.

835. In this subclass are included the Polypetalous orders of Jussieu, in which the stamens are not hypogynous, as well as some monopetalous and diclinous orders. A calyx and corolla are present, in other words, the plants are Dichlamydeous; the petals are distinct or united, and the stamens are attached to the calyx,—being Perigynous or Epigynous. This subclass, along with Thalamifloræ, comprises the Dialypetalæ of Endlicher. There is also included in it the Gamopetalæ in which the ovary is inferior.

Section 1.—POLYPETALÆ. Petals separate, stamens Perigynous or Epigynous.

836. Order 61.—**Stackhousiaceæ,** the Stackhousia Family. (*Polypetal. Perigyn.*) Calyx 5-cleft, equal, with an inflated tube. Petals 5, equal, inserted at the top of the tube of the calyx, claws of the petals united, limb narrow and stellate. Stamens 5, unequal, attached to the tube of the calyx. Ovary superior, 3-5-celled, cells partially distinct; ovules solitary, erect; styles 3-5, sometimes united at the base; stigmas simple. Fruit consisting of 3-5 indehiscent pieces, which are sometimes winged, and are attached to a central persistent column. Seeds anatropal; embryo long, erect, in the axis of fleshy albumen.—Shrubs with simple, entire, alternate, stipulate, leaves, found in New Holland, and not possessing any marked properties. Lindley notices 2 genera, and 10 species. *Example*—Stackhousia.

837. Order 62.—**Celastraceæ,** the Spindle-tree Family. (*Polypet. Perigyn.*) Sepals 4-5, imbricated in æstivation. Petals 4-5, with a broad base, and an imbricated æstivation, rarely wanting. Stamens alternate with the petals; anthers erect. Disk large, flat, and expanded, surrounding the ovary to which it adheres. Ovary superior, 2-5-celled; ovules ascending, one or numerous, attached to the axis by a short funiculus. Fruit either a 2-5-celled capsule, with loculicidal dehiscence, or drupaceous. Seeds one or many in each cell, anatropal, usually ascending, and sometimes arillate (figs. 481, 482); albumen fleshy; embryo straight, with flat cotyledons and a short radicle.—Small trees or shrubs, with simple, alternate, rarely opposite leaves, and small deciduous stipules. They inhabit the warm parts of Europe,

North America, and Asia, and many are found at the Cape of Good Hope. The order contains 35 known genera, and 282 species. It has been divided into two tribes:—1. Euonymeæ, with capsular fruit, 2. Elæodendreæ, with drupaceous fruit. *Examples*—Celastrus, Euonymus, Elæodendron.

838. The plants of the order have subacrid properties, and the seeds of some yield a useful oil. Those of *Celastrus nutans*, or *paniculatus*, are said in India to be of a stimulant nature, and to be used as a remedy in the disease called Beriberi. Some of the species of *Celastrus*, as *C. venenatus*, are reckoned poisonous. The seeds of *Euonymus*, Spindle-tree, are surrounded by an aril, or rather arillode, which is considered as a prolongation from the exostome (figs. 481, 482). In some of the species the capsules are crimson, and with the bright scarlet arillodes, they present a very showy appearance when the fruit is ripe. The bark of *Euonymus tingens* furnishes a yellow dye. It is used to mark the tika on the forehead of the Hindoos. It is also considered useful in diseases of the eye. The young shoots of *Euonymus europæus*, when charred, are used to form a particular kind of drawing pencil; its fruit and inner bark are said to be purgative and emetic.

839. Order 63.—**Staphyleaceæ,** the Bladder-nut Family. (*Polypet. Perigyn.*) (Fig. 539.) Sepals 5, united at the base, coloured, imbricated in æstivation. Petals 5, alternate, with an imbricated æstivation. Stamens 5, alternate with the petals. Disk large and urceolate. Ovary 2-3-celled, superior; ovules usually ascending; styles 2-3, cohering at the base. Fruit membranous or fleshy, indehiscent or opening internally, often partly abortive. Seeds anatropal, roundish, truncate at the hilum, with a bony testa; albumen generally 0; embryo straight, with thick cotyledons and a small inferior radicle.—Shrubs, with opposite, pinnate leaves, having stipules and stipels (¶ 161). By many authors they are included under the last order. The plants are irregularly scattered over the globe, and are found in Europe, America, and Asia. Some of them appear to be subacrid, while others are bitter and astringent. The species of *Staphylea* receive the name of bladder-nut, on account of their inflated bladder-like pericarp. They are cultivated as handsome shrubs. Three known genera are enumerated, and 14 species. *Example*—Staphylea.

840. Order 64.—**Rhamnaceæ,** the Buckthorn Family. (*Polypet. Perigyn.*) Calyx 4-5-cleft, valvate in æstivation. Petals distinct, hooded or convolute, inserted into the throat of the calyx, sometimes 0. Stamens definite, opposite the petals. Disk large, fleshy, flat or urceolate. Ovary superior or half superior, 2-3 or 4-celled; ovules solitary, erect, anatropal. Fruit fleshy and indehiscent, or dry and separating into three parts. Seeds erect; albumen fleshy, rarely 0; embryo about as long as the seed, with a short inferior radicle, and large flat cotyledons.—Trees or shrubs, often spiny, with simple, alter-

nate, rarely opposite leaves, and minute stipules. They are generally distributed over the globe, and are found both in temperate and tropical regions. There are 46 genera, and 266 species enumerated. *Examples*—Rhamnus, Ceanothus, Phylica, Pomaderris.

841. Many of the plants of the order have active cathartic properties. Some, however, yield edible fruit, and others are tonic and febrifugal. *Rhamnus catharticus*, common or purging Buckthorn, is a European shrub, the black succulent fruits or berries of which are used as a hydragogue cathartic in cases of dropsy. The greenish juice becomes gradually red by the formation of acetic acid in it. It may be preserved unchanged in the form of syrup. When mixed with lime and evaporated to dryness, it forms the colour called sap-green. The fruit of *Rhamnus Frangula* , Black Alder, is emetic and purgative. The berries of *Rhamnus infectorius*, as well as those of other species, are known by the name of French berries. They have been used for dyeing yellow. The fruit of many species of *Zizyphus* is used for food; *Zizyphus Jujuba* supplies the fruit called Jujube; and the Lotus, or Lote-bush of the classics, whence the Lotophagi were named, is *Zizyphus Lotus*. A kind of Scinde lac is found on *Zizyphus Jujuba*. *Paliurus aculeatus*, Christ's-thorn, is common in the hedges of Judæa. *Ceanothus Americanus* is used in America as an astringent, and its leaves, under the name of New Jersey Tea, have been used as a substitute for tea. The leaves of *Sageretia theezans* are used for the same purpose by the poorer classes in China.

842. Order 65.—**Anacardiaceæ**, the Cashew-nut Family. (*Polypet. Perigyn.*) Flowers usually unisexual. Calyx usually small and persistent, with 5, or sometimes 3-4-7 divisions. Petals equal in number to the calycine divisions, perigynous, sometimes 0; imbricated in æstivation. Stamens either equal to the petals in number and alternate with them, or twice as many or more; filaments distinct or cohering at the base, usually perigynous. Disk fleshy, annular or cup-shaped, sometimes inconspicuous. Ovary single, rarely 5 or 6, free or adhering to the calyx, 1-celled; ovule solitary, attached by a funiculus to the bottom or along the side of the cell; styles 1-3, occasionally 4; stigmas 1-3 or 4. Fruit usually drupaceous and indehiscent. Seed ascending or frequently pendulous, from the adherence of the funiculus to the angle of the cell, exalbuminous; radicle inferior or superior, sometimes curved suddenly back; cotyledons thick, fleshy, or leafy.—Trees or shrubs, with a resinous, often caustic juice, and alternate leaves without dots. The order is a subdivision of the Terebinthaceæ of Jussieu. The plants inhabit chiefly the tropical parts of America, Africa, and India; some, however, are found in Europe. The order is unknown in New Holland. There are 55 known genera, and 116 species. *Examples*—Anacardium, Rhus, Mangifera, Spondias.

843. The order is characterized by the presence of an acrid resinous juice. In some cases, however, the fruit of the plants is edible. Many of them supply varnishes. *Anacardium occidentale* furnishes the Cashew-nut, which is remarkable for its large succulent peduncle supporting the fruit or nut (fig. 227). The pericarp has the acrid properties which pervade the order, while the seed is eatable. The fleshy peduncle is acid and edible, and a bland gum exudes from the bark. *Pistacia vera* is the Pistacia or Pistachio nut-tree, which extends from Syria to Bokhara and Caubul, and is cultivated in the south of Europe. It has green-coloured oily kernels, which are used as articles of diet. *P. Terebinthus* is a native of the southern part of Europe, and the northern part of Africa, and yields a liquid resinous exudation, known as Chian turpentine. The turpentine receives its name on account of being collected in the island of Chio or Scio, where the plant thrives. The tree attains a height of 30 or 35 feet, and one tree will yield ten ounces of the liquid resinous matter, which thickens on exposure to air, by the loss of volatile oil. Like other turpentines, it has diuretic and excitant properties. *Pistacia Lentiscus*, a native of the coasts and islands of the Mediterranean, furnishes the concrete resinous exudation called Mastiche or Mastic. It is a bush of about 10 or 12 feet in height, which is cultivated abundantly in the island of Chios. Mastic is used as a masticatory for consolidating the gums and cleansing the teeth. It has also been employed as an antispasmodic, and it enters into the composition of varnishes. *Rhus Toxicodendron*, Poison-oak, is a shrub found in Canada and the United States, the leaves of which have been used as stimulants in cases of palsy. Like the other species of this genus, it yields an acrid milky juice, which becomes black on exposure to the air. *Rhus radicans*, Poison-ivy, or Poison-vine, is probably another name of the same species. *Rhus venenata*, Poison-sumach, or Poison-elder, has acrid, poisonous properties, and contact with it, in some instances, gives rise to inflammation of the skin. Cases are related of persons who are peculiarly liable to be thus affected, and in whom the irritation caused by the juice of the poisonous species of Rhus is very great, and even alarming. *Rhus coriaria*, *R. typhina*, and *R. glabra* are used for tanning, and their fruit is acid. *Rhus Cotinus* is called *Arbre à perruque* in France, on account of the hairy appearance presented by its abortive pedicels. Many of the plants in this order furnish varnishes and marking ink. *Semecarpus Anacardium*, commonly called the Marking-nut tree, supplies the Sylhet varnish, while *Melanorrhœa usitatissima* furnishes that of Martaban. *Stagmaria verniciflua* is the source of the hard black varnish called Japan Lacquer. The leaves of many of the species of *Schinus*, as *S. Molle*, when broken and thrown on the surface of water, send out a resinous matter with great force, so as to cause a sort of spontaneous motion by the recoil.

Although a resinous principle pervades the plants of this order, yet in some cases it is not developed in the fruit, which becomes eatable. Of this an illustration is furnished by the Mango, the produce of *Mangifera indica*. The Hog-plums of the West Indies are furnished by various species of *Spondias*, as *S. purpurea* and *Mombin*.

844. Order 66.—**Amyridaceæ**, the Amyris Family. (*Polypet. Perigyn.*) Flowers usually bisexual, sometimes unisexual by abortion. Calyx persistent, regular or nearly so, with 2 to 5 divisions. Petals 3-5, inserted at the base of the calyx; æstivation valvate or imbricated. Stamens twice or four times as many as the petals, perigynous. Disk covering the base of the calyx often in a ring-like manner. Ovary superior, sessile, 1-5 celled; ovules in pairs, anatropal, pendulous or suspended; style 1 or none; stigma simple or lobed, sometimes capitate. Fruit dry, 1-5-celled, indehiscent, or its epicarp splitting into valves. Seeds solitary, exalbuminous, with a superior radicle next the hilum, and cotyledons, which are fleshy or wrinkled.—Trees or shrubs, abounding in resin, with opposite or alternate compound leaves, which are frequently stipulate and dotted. They are natives of tropical regions. There are two suborders:—1. Amyrideæ, with an unilocular ovary. 2. Bursereæ, with a 2-5-celled ovary. Some look upon the stamens of Amyrideæ as truly hypogynous, and consider the order as allied to Aurantiaceæ. Authors give 26 genera, and 56 species. *Examples*—Amyris, Boswellia, Bursera, Balsamodendron.

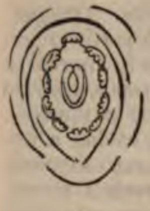
845. The plants yield a fragrant balsamic and resinous juice, which, in a dry state, is often used as frankincense, and is employed medicinally as a stimulant or expectorant. The resinous substance called Elemi seems to be obtained from one of the plants of this order. Linnæus referred it to *Amyris elemifera*, under which name several species seem to be included. Some authors think that *Icica Icicariba* furnishes elemi in Brazil, while Royle refers a Mexican kind to *Elaphrium elemiferum;* and other varieties, according to Christison, are probably the produce of *Canarium commune* and *balsamiferum*. The resin contains a stimulant volatile oil. *Boswellia serrata*, a large Indian tree, supplies the gum-resin called olibanum, or the true frankincense of the ancients, the לְבֹנָה of the Scriptures. It contains a volatile oil, and has been used as a stimulant, and as a material for fumigation. *Balsamodendron* (*Protium?*) *Myrrha*, a shrub growing in Abyssinia, appears to be the source of the officinal myrrh, the מֹר of the Bible. It is a bitter aromatic gum-resin, containing volatile oil, and was used in ancient times as frankincense. It is a heating stimulant, and is employed medicinally as an emmenagogue and diaphoretic, as well as for arresting various mucous discharges. The resin called Bdellium is procured from various species of *Balsamodendron*, as *B. africanum* and *Roxburghii*. The celebrated balsam called Balm of Gilead, is an exudation from *Balsamodendron gileadense*. Tacamahac

is procured from *Elaphrium tomentosum*. Various other balsams and resins are yielded by plants of this order. *Amyris toxifera* is said to be poisonous.

846. Order 67.—**Connaraceæ**, the Connarus Family. (*Polypet. Perigyn.*) Flowers bisexual, rarely unisexual. Calyx 5-partite, regular, persistent; æstivation imbricate or valvate. Petals 5, inserted at the base of the calyx. Stamens twice as many as the petals, inserted with them, and doubtfully hypogynous; filaments united at the base. Ovary consisting of one or more separate carpels, each having a terminal style, and a dilated stigma; ovules in pairs, collateral, ascending, orthotropal. Fruit follicular, dehiscing along the ventral suture. Seeds solitary or in pairs, erect, with or without albumen, sometimes arillate; embryo with a superior radicle, remote from the hilum, and cotyledons, which are either fleshy or leafy.—Trees or shrubs, with compound, alternate, exstipulate leaves, which are not dotted. They are tropical plants, and according to Endlicher are common in America. Some of them have febrifugal properties. *Omphalobium Lamberti* is said to furnish Zebra-wood. This order, as well as the orders Anacardiaceæ and Amyridaceæ, are by many considered truly hypogynous, and as belonging to Thalamifloræ. Lindley includes them in his Rutal alliance He notices 5 genera, and 42 species. *Examples*—Connarus, Omphalobium, Cnestis.

847. Order 68.—**Leguminosæ** (Fabaceæ of Lindley), the Pea and Bean Tribe. (*Polypet. Perigyn*). Calyx 5-partite, toothed, or cleft (figs. 593, 594 *c c*), with the odd segment anterior (¶ 357); segments often unequal and variously combined. Petals 5 (figs. 593, 594), or by abortion, 4, 3, 2, 1, or 0, inserted into the base of the calyx, sometimes equal, but usually unequal, often papilionaceous, with the odd petal superior (fig. 594 *e*). Stamens definite or indefinite, usually perigynous, distinct, or monadelphous or diadelphous (fig. 594 *t*), or rarely triadelphous; anthers bilocular, versatile. Ovary superior, 1-celled, consisting usually of a solitary carpel (fig. 594 *o*), sometimes of 2-5; ovules 1 or many; style simple, proceeding from the upper or ventral suture; stigma simple (fig. 594 *s*). Fruit a legume (figs. 440, 469, 595), or a drupe. Seeds solitary or several (fig. 595), sometimes arillate, often curved (fig. 596); embryo usually exalbuminous, straight, or with the radicle bent upon the edges of the cotyledons (figs. 429, 516), which are either epigeal or hypogeal (¶ 629) in germination (fig. 597), and leafy (Phyllolobæ) or fleshy (Sarcolobæ).—Herbaceous plants, shrubs, or trees, with alternate, usually compound leaves, having two stipules at the base of the petiole (fig. 193), and two at the base of each leaflet in the pinnate leaves. Pedicels usually articulated. The flowers are frequently papilionaceous (fig. 292), and the fruit is commonly leguminous (figs. 460, 469, 470, 471), and by the presence of one or other of these characters the order may be recognized. It is remarkable that one or other of these dis-

tinctions disappears in a great number of cases. Cæsalpinieæ have irregular flowers with spreading petals and stamens adhering to the calyx; others have no petals at all, or some number less than five; while Mimoseæ have perfectly regular flowers and indefinite hypogynous stamens. Detarium and other plants of this family bear fruits not to be distinguished from a drupe. Leguminous plants and Roseworts have so many features in common that it may be affirmed that no positive character has been discovered to distinguish the one order from the other, except the inferior position of the odd calycine lobe.



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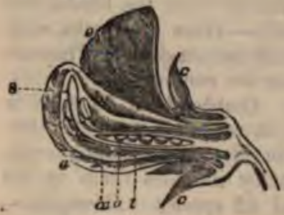

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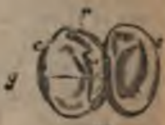


597

848. The plants of the order are very generally distributed over the globe, but many genera are very limited in their range. De Candolle gives the following geographical distribution of the 3600 species known in his day:—

Figs 593-597.—Organs of fructification of Lathyrus oderatus, Sweet-pea, a papilionaceous flower, showing the structure of the natural order Leguminosæ.

Fig 593.—Diagram of the flower, showing five divisions of the calyx, 5 petals, consisting of 2 parts forming the carina, 2 alæ, and the vexillum, which is superior, 10 stamens in 2 rows, diadelphous; ovary 1-celled, formed by a single carpel; one of the ovules shown with its funiculus attached to the ventral suture.

Fig. 594.—Longitudinal section of the flower of Lathyrus odoratus. *c c*, Calyx, with five segments. *e*, Vexillum or standard, being the superior or posterior odd petal. *a*, One of the alæ or wings. *c*, *a*, One-half of the carina, or keel. *t*, Tube of the stamens, the filaments being united in two bundles, or diadelphous. *o*, Ovary laid open, showing the ovules attached to the placenta on the ventral or upper suture. *s*, Stigma, at the apex of the style, which is continuous with the ventral suture.

Fig 595.—Fruit, a Legume or Pod, opening by two valves, and dehiscing by the ventral and dorsal suture. Seeds attached on each side of the ventral suture, curved upon themselves, having a marked hilum and funiculus (podosperm or umbilical cord).

Fig. 596.—A seed separated. *f*, Funiculus. *c*, Chalaza united to the funiculus by the raphe. *m*, Micropyle or foramen.

Fig. 597.—Embryo, which occupies the entire seed after the spermoderm is removed. *c*, *c*, Two *cotyledons* separated; they are fleshy and hypogeal, *i.e.* remain under ground during germination. *g*, Gemmule or plumule. *r*, Radicle.

Equinoctial America	605
Basin of the Mediterranean	468
East Indies	452
Cape of Good Hope	353
Levant	250
New Holland	229
West Indies	221
Europe, excepting the Mediterranean	184
United States	183
Mexico	152
Equinoctial Africa	130
Siberia	129
Arabia and Egypt	87
China, Japan, Cochin-China	77
Isles of Southern Africa	42
South America, beyond the tropics	29
Canaries	21
South Sea Islands	13

It is said that no native species occur in the islands of Tristan d'Acugna and St. Helena.

The order has been divided into three suborders:—1. Papilionaceæ; papilionaceous flowers, petals imbricated in æstivation, and upper one exterior. This suborder is subdivided into the tribes Podalyrieæ, Loteæ, Vicieæ, Hedysareæ, Phaseoleæ, Dalbergieæ, Sophoreæ; according to the nature of the filaments, whether free or variously united, the form and dehiscence of the legume, the cotyledons whether fleshy or leafy, and the simple or compound nature of the leaves. *Examples*—Podalyria, Lotus, Cytisus, Pisum, Hedysarum, Phaseolus, Dalbergia. 2. Cæsalpinieæ; flowers irregular, sub-papilionaceous, petals spreading, imbricated in æstivation, upper one interior. *Examples*—Hæmatoxylon, Cæsalpinia, Cassia, Swartzia, Amherstia, Bauhinia, Copaifera, and Ceratonia. 3. Mimoseæ; flowers regular, petals valvate in æstivation. *Examples*—Parkia, Mimosa, Acacia.

The number of known genera at the present day is about 550, including upwards of 7000 species. The following is the estimate of species in the different suborders and tribes, considered in reference to the flora of the globe and the flora of Britain (Bentham and Henslow):—

Suborders.	Tribes.	Species.	British species.
1. Papilionaceæ	1. Podalyrieæ	350	0
	2. Loteæ with	3000	48
	Vicieæ....		23
	3. Hedysareæ	500	4
	4. Phaseoleæ	650	0
	5. Dalbergieæ	250	0
	6. Sophoreæ	50	0
2. Cæsalpinieæ		700	0
3. Mimoseæ		1000	0
		6500	75

849. This is a very extensive and a very important natural order. It embraces many valuable medicinal plants, such as those yielding Senna, Gum-arabic, Tragacanth, Catechu, and Kino; important dyes, as Indigo and Logwood; many valuable timber trees, as Locust-tree and Rosewood; plants furnishing nutritious food, such as the Bean and Pea. The properties of the order may be considered in general as wholesome, although it contains some poisonous plants. Lindley, however, says that the order must be considered upon the whole as poisonous, and that the plants used for food are exceptions to the general rule; the injurious juices of the order not being in such instances sufficiently concentrated to prove injurious, being replaced to a considerable extent by either sugar or starch.

850. Suborder *Papilionaceæ.* The plants in this section have frequently beautiful showy flowers; for example, *Robinia*, *Laburnum*, *Wistaria*, *Lupinus*, *Clianthus*, *Erythrina*, or Coral-flower, *Hovea*. They are often nutritious. The various kinds of Clover, Beans, Peas, and Pulse belong to it. The common red Clover is *Trifolium pratense*. White or Dutch Clover (*T. repens*) springs up frequently on ground recently cleared. The Shamrock is generally considered as a species of Trefoil. Various species of Medick and Lucerne (*Medicago*, fig. 471), of Saintfoin (*Onobrychis*), and Melilot (*Melilotus*), are cultivated as food for cattle. Many are used for their medicinal qualities. *Glycyrrhiza glabra*, or *Liquiritia officinalis*, is the plant which yields liquorice-root. This plant is a native of the southern part of Europe, and it has been occasionally cultivated with success in Britain, especially at Pontefract in Yorkshire, and at Mitcham in Surrey. An extract is prepared from the root or underground stem by decoction in water, and subsequent inspissation. It owes its sweetness to a peculiar principle called Glycion, or Glycyrrhizin, which appears also to be present in the root and leaves of other papilionaceous plants, as *Glycyrrhiza echinata* and *glandulifera*, *Trifolium alpinum*, and *Abrus precatorius*. Liquorice is used medicinally as a demulcent. A sweet secretion (a kind of Manna) is produced by *Alhagi Maurorum*. *Astragalus verus*, *creticus*, *aristatus*, *gummifer*, and other species, yield an exudation known by the name of Gum Tragacanth. *A. verus* seems to be the chief source of the European tragacanth. It is a shrub found in Asia Minor and Persia, and the gum is procured by exudation or incision. Tragacanth forms with cold water a bulky jelly, while it is soluble in boiling water. It contains both Arabin and Bassorin in its composition, and is used as a demulcent. *Myrospermum*, or *Myroxylon peruiferum*, yields the Balsam of Peru, while *Myrospermum*, or *Myroxylon toluiferum*, is the source of the Balsam of Tolu. These balsams are procured chiefly by making incisions in the trees. They consist of resinous and oily matter, with cinnamic acid, and they are used as stimulant expectorants. *Pterocarpus Marsupium*, a tree of the Indian forests, furnishes the concrete exuda-

on called Kino. *Butea frondosa*, or the Dhak tree of the East Indies, ields a similar product; it has bright orange-red petals, and a lack calyx. African Kino is procured from *Pterocarpus erinaceus*. ino is used as a powerful astringent, and is administered in the orm of powder and tincture. Broom-tops, procured from *Cytisus* *Sarothamnus*) *Scoparius*, are used as a diuretic. The hairs from the egumes of *Mucuna pruriens* in the West Indies, and of *M. Prurita* n the East, under the name of Cowhage, or Cowitch, have irritating properties, and, mixed with syrup, they are used in the treatment of intestinal worms. The leaves of *Colutea arborescens*, Bladder-Senna (fig. 470), are purgative, and are used abroad to adulterate the obovate or blunt-pointed Senna. The leaves of *Tephrosia apollinea* are also purgative, and are occasionally mixed with Alexandrian Senna. The bark of *Andira inermis*, the Cabbage-tree of the West Indies, acts as a purgative and anthelmintic. The fruit of *Geoffroya superba*, Umari, is much used by the inhabitants of Brazil on the banks of the Rio San Francisco; the fruit is a drupe.

Besides the plants which have active medicinal qualities, there are others which are valuable in commerce and the arts, as furnishing food, dyes, fibres, timber. Various species of *Indigofera*, as *I. tinctoria* and *cærulea*, furnish the Indigo of commerce. *Pterocarpus santalinus* yields red Sandal-wood, which is used as a dye. *P. Draco* yields Gum-Dragon, and *P. Dalbergioides* is said to yield Andaman redwood, nd to be valuable both as a dye and as timber. *Baptisia tinctoria* ives a blue dye, and is the wild Indigo of the United States. *Dal-* *rgia Sissoo* is an Indian forest tree, which is valued on account of its od. *Crotalaria juncea* supplies fibres, which are known as Sun or ngal Hemp. The fragrant seeds of *Dipterix odorata* are known as nka-beans. A similar fragrance is given out by some species of ilot, the flowers and seeds of which are employed to give the liar odour to Gruyere cheese. *Arachis hypogæa* produces its mes under ground, and receives the name of under-ground Kidney- , or Ground-nut. *Erythrina monosperma* yields Gum lac. The of *Glycine Apios*, or *Apios tuberosa*, are used as an article of food merica. *Robinia pseudo-acacia* is often cultivated in Britain as ocust-tree. The tree attains in England a height varying from ive to eighty feet, and sometimes has a diameter of three feet. od is durable. According to Bertoloni, a kind of Ebony is the e of *Fornasinia ebenifera*, a papilionaceous plant, found in a, near Mozambique. Rosewood is said to be the timber of three species of *Trioptolomea*. It is rare to find papilionaceous roduce double flowers. The Whin is one of the plants which this monstrosity. *Desmodium* or *Hedysarum gyrans* exhibits kable irritability in its leaves (¶ 660). There are certain s plants in this suborder. The seeds and bark of *Cytisus*

Laburnum are narcotic; such is said also to be the case with those of *Lathyrus Cicera*, and *L. Aphaca*. The roots of many species of *Phaseolus*, as *P. multiflorus*, the Scarlet-runner, and *P. radiatus*, are poisonous. The branches and leaves of *Tephrosia toxicaria*, and the bark of the root of *Piscidia erythrina*, Jamaica Dogwood, are employed as fish poisons. *Physostigma venenosum* yields the Calabar ordeal-bean. *Gompholobium uncinatum* has poisoned sheep in the Swan River colony. *Coronilla varia* acts as a narcotic poison. The leaves of it and of *Coronilla Emerus* are sometimes used to adulterate Senna.

851. Suborder *Cæsalpinieæ*. In this section there are many plants which furnish purgative remedies. Among these may be noticed various species of *Cassia*. *C. lanceolata*, *acutifolia*, *elongata*, *obtusata*, and *obovata*, supply the various kinds of Senna known as Alexandrian or Egyptian, Tripoli, and East Indian Senna. Other species also, as *Cassia marilandica*, *Absus*, *corymbosa*, *biflora*, *tomentosa*, *alata*, and *Porturegalis*, have purgative leaves. *Cassia Fistula*, called also *Cathartocarpus Fistula*, has an indehiscent pod, divided by numerous transverse phragmata (fig. 395), and containing a laxative pulp, which is a secretion from the endocarp. A pulp having similar properties is procured from the pericarp of *Tamardinus indica*, the Tamarind-tree. The pod of *Ceratonia Siliqua* is known as the Algaroba-bean, and is used occasionally for feeding horses. The tree is denominated Carob-tree, and sometimes Locust-tree, or St. John's Bread, from an erroneous idea that the pods supplied food to John the Baptist in the wilderness. The pods of *Hymenæa Courbaril*, the West Indian Locust-tree, supply a nutritious matter; its inner bark is anthelmintic, and the plant yields a kind of resin called Anime. The bark of *Guilandina Bonduc*, the Nicker-tree, is bitter, tonic, and its seeds are said to be emetic. The curved pods of *Cæsalpinia coriaria*, under the name of Dividivi, are used for tanning. *Cæsalpinia brasiliensis* yields the Brazilwood of commerce, and the Mora-wood of Guiana is yielded by a large tree called *Mora excelsa*. Many dyes are furnished by the plants of this suborder. *Hæmatoxylon campechianum* gives Logwood or Campeachy-wood, which is employed both as a dye and as an astringent. The inner wood is the part employed both in the arts and officinally. The alburnum is of a yellowish colour, and is not imported. The red colouring principle is Hæmatoxylin. *Cæsalpinia echinata* furnishes Pernambuco-wood; *C. sappan*, Sappan-wood, the Wukkum or Bukkum-wood of Scinde; *Baphia nitida*, Camwood. Various species of *Copaifera*, as *C. Jacquinii*, *Langsdorfii*, *bijuga*, *multiguga*, *Martii*, *Guianensis*, *coriacea*, &c., furnish the Balsam of Copaiva, of which two kinds are distinguished—the West Indian and Brazilian. The balsam contains a resin and volatile oil. It is used in medicine as a stimulant, cathartic, and diuretic, and is especially employed in the treatment of mucous inflammations. *Cassia Chamæ-*

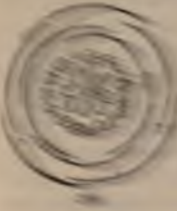
ista, *marilandica*, and *nictitans*, all exhibit, according to Bromfield, high degree of irritability; the leaflets close together almost as soon s gathered, and even when rudely handled or brushed by the feet in alking through the herbage.

852. Suborder *Mimoseæ*. The plants of this section yield Gum in rge quantity, and their bark is frequently astringent. *Acacia hrenbergii*, *tortilis*, *Seyal*, *arabica*, *vera*, *gummifera*, *Adansonii*, *Verek*, *lbida*, and various other species, yield the gummy substances known s Gum Arabic, Gum Senegal, Barbary Gum, and East Indian Gum. kind of gum is procured at the Cape of Good Hope from *Acacia arroo*, and in New Holland, *A. decurrens* yields another variety. A ariety of Indian gum procured from *A. arabica*, is called Babul, or abool-Gum; Babul-wood is used for tanning in Scinde. These ums are all more or less nutritive and demulcent, and are administered n the form of mucilage, emulsion, or lozenges. The Wattles of Australia are species of *Acacia*, which furnish astringent barks. An extract made from them has been imported for the purpose of tanning. The inner wood of *Acacia Catechu*, an Indian shrub, furnishes a kind of Catechu, or Cutch, which contains much tannin, and is used for tanning, and as a powerful astringent. Some of the New Holland Acacias are remarkable for the peculiar development of the petiole, which assumes the form of a phyllodium (fig. 188 *p*). The large seeds of *Entada scandens* are sometimes carried by the winds and tides from the West Indies to the shores of the outer Hebrides. *Acacia Seyal* is supposed to be the Shittah Tree of Scripture which furnished Shittim wood. *A. formosa* supplies the Cuba timber called Sabicu. Some of the plants in this suborder display peculiar irritability in their pinnate leaves. This is particularly the case with *Mimosa sensitiva* and *pudica*, which are commonly called sensitive plants (¶ 659). Almost all of the pinnate-leaved Leguminous plants close their leaves in a marked way during darkness.

853. Order 69.—**Moringaceæ**, the Moringa Family. (*Polypet. Perigyn.*) Calyx 5-partite; æstivation slightly imbricated. Petals 5, rather unequal, upper one ascending. Stamens 8 or 10, perigynous; filaments slightly petaloid, callous, and hairy at the base; anthers simple, 1-celled, with a thick convex connective. Disk lining the tube of the calyx. Ovary superior, stipitate, 1-celled; ovules anatropal, attached to parietal placentas; style filiform; stigma simple. Fruit a pod-like capsule, 1-celled, 3-valved, opening by loculicidal dehiscence. Seeds numerous, half buried in the spongy substance of the valves, sometimes winged, exalbuminous; embryo with a superior, straight, small radicle, and fleshy cotyledons.—Trees, with bi- or tripinnate, stipulate leaves, natives of the East Indies and Arabia. Some of them are pungent and aromatic. The seeds of *Moringa pterygosperma*, Horse-radish tree, are winged, and are called Ben-nuts. From

[illegible] expressed a fluid oil, used by watchmakers, and called Oil of Ben. The root is pungent and stimulant, and resembles Horse-radish in its taste. It is used as a stimulant in paralytic affections and in intermittent fever. It is also a rubefacient. Lindley places this order in his Violal alliance. He mentions 1 genus, and 4 species. *Example*—Moringa.

884. Order 75.—Rosaceæ, the Rose Family. (*Polypet. Perigyn.*) (Figs. 236, 238, 286, 276, 289, 386, 598). Calyx 4-5-lobed (fig. 599 *c c*), the fifth lobe superior. Petals as many as the divisions of the calyx, often 5 (fig. 599 *p e*), sometimes wanting, perigynous, generally regular; æstivation quincuncial (fig. 598). Stamens inserted with the petals (fig. 599 *e*), definite or indefinite; filaments incurved in æstivation; anthers bilocular (fig. 600) dehiscing longitudinally



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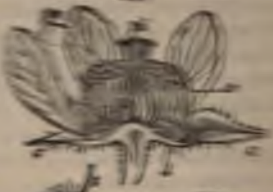

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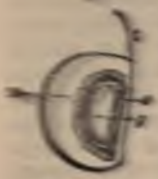

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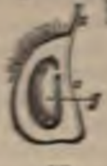

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Figs. 598-605.—Organs of fructification of Rubus strigosus, illustrating the natural order Rosaceæ.

Fig. 598.—Diagram of the flower, with five divisions of the calyx, 5 quincuncial petals, indefinite [illegible] stamens, and numerous unovulate carpels.

—The flower cut vertically. *c c*, Calyx. *pe*, Petals. *e*, Stamens. *d*, Disk, lining the calyx, upon which the stamens are inserted. *pi*, Pistil composed of several

Bilocular anther separated with the upper part of the filament, seen on the outside.

Ovary, *o*, cut vertically. *g*, Exalbuminous, suspended seed. *s*, Lateral style.

Fruit. *f*, Fleshy carpels accompanied with the persistent calyx, *c*, connected with withered filaments are seen.

Vertical section of a carpel. *s*, Lateral Style. *m*, Fleshy mesocarp or sarcocarp. *g*, Seed.

Horizontal section of the exalbuminous seed. *t*, Integument (spermoderm). *e*, Embryo.

Embryo isolated. It fills the entire seed.

322). Ovaries superior, either solitary or several, unilocular 601), sometimes uniting so as to form a many-celled pistil; s 1, 2, or more, anatropal, suspended (figs. 373 *g*, 601 *g*), rarely ; styles lateral (figs. 400, 601, 603); stigmas usually simple. either achænia (fig. 270) or drupes (figs. 373, 602), or follicles mes (fig. 472). Seeds erect or inverted, usually exalbuminous; yo straight, with the radicle next the hilum (figs. 603, 605,) and or fleshy cotyledons (figs. 501, 604).—Herbaceous plants, or s, or trees, with simple or compound, alternate, stipulate leaves 191), and the flowers sometimes unisexual. They are found y in the cold and temperate climates of the northern hemisphere. are found on high mountains within the tropics, and a few occur rm regions. The superior odd lobe of the calyx distinguishes this from Leguminosæ.

e order has been divided into the following suborders:—1. obalaneæ, petals and stamens more or less irregular; ovary te, its stalk adhering on one side to the calyx, style basilar 401), fruit a 1-2-celled drupe. 2. Amygdaleæ (Drupaceæ of ey), tube of calyx lined with a disk, styles terminal, fruit a drupe 308, 371-373). 3. Spiræeæ, calyx-tube herbaceous, lined with a ruit consisting of numerous follicles, seeds apterous. 4. Quillaieæ, s unisexual, calyx-tube herbaceous, fruit capsular, seeds winged e apex. 5. Sanguisorbeæ, petals 0, tube of calyx thickened and ated, lined with a disk, stamens definite, not solitary, enclosed in lycine tube. 6. Potentilleæ, calyx-tube herbaceous, lined with which sometimes becomes fleshy, fruit consisting of numerous ia. 7. Roseæ, calyx-tube contracted at the mouth, becoming , lined with a disk, and covering numerous hairy achænia (figs. 289). 8. Pomeæ (Pomaceæ of Lindley), tube of calyx more or lobose, lined with a fleshy and juicy disk, fruit a 1-5-celled 172) or spuriously 10-celled pomum. There are 95 known , and about 1084 species. *Examples*—Chrysobalanus, Amyg- Prunus, Spiræa, Quillaia, Sanguisorba, Potentilla, Rubus, ria, Rosa, Pyrus.

. Many of the plants of the order yield edible fruits, such as erries, Strawberries, Brambles, Plums, Apples, Pears, Quinces, es, Almonds, Peaches, Nectarines, and Apricots. Some are gent, others yield hydrocyanic acid. Those belonging to the ler *Chrysobalaneæ*, are principally natives of the tropical parts ica and America. Many of them furnish edible fruits. The of *Chrysobalanus Icaco*, are eaten in the West Indies under me of Cocoa-plums. The root and bark are used as astrin-

plants in the suborder *Amygdaleæ*, are chiefly remarkable on t of the presence of hydrocyanic acid in their kernels, leaves, or flowers. *Amygdalus communis*, the Almond-tree, grows naturally in Barbary and in Asia, from Syria to Affghanistan. It is extensively cultivated in the south of Europe. There are two varieties of the tree,—α. *dulcis*, yielding the sweet Almond, and β. *amara*, yielding the bitter Almond. In the former, the style is much longer than the stamens, and there are glands on the base of the leaf; while in the latter, the style is equal in length to the stamens, and the glands are situated on the petioles. The chief kinds of sweet Almonds are the Valentia, the Italian, and the Jordan Almonds; the latter come from Malaga. Under the name of shell Almonds, they are often sold with the brittle endocarps on them. They consist chemically of a bland fixed oil, and a kind of vegetable albumen called Emulsin or Synaptase. Bitter Almonds are imported from Mogadore. Besides a fixed oil and synaptase, they contain a bitter azotised principle called Amygdalin, which, when brought into contact with a solution of Emulsin, produces a volatile oil, containing hydrocyanic acid. This gives rise to the peculiar aroma of bitter Almonds, when mixed with water. Sweet Almonds are used medicinally, in the form of Emulsion, as demulcents. The hydrocyanated essential oil of bitter Almonds is sedative, and has been used as a substitute for Prussic acid. They sometimes produce derangement of the digestive functions, and give rise to nettle-rash. The leaves of *Amygdalus persica* (*Persica vulgaris* of some), the Peach, contain a similar oil, and have been employed as sedative and vermifuge. The flowers of the Peach exhale the odour of bitter Almonds. Peaches are divided into Freestone and Clingtsone, according as the pulp (sarcocarp) separates easily from the endocarp or adheres to it. The fruit of *Prunus domestica*, the Plum-tree and its varieties, when dried, constitute Prunes, which are used medicinally, on account of their nutritive and laxative qualities. The leaves of *Prunus* or *Cerasus Laurocerasus*, Cherry Laurel, or common Bay Laurel, have been used medicinally, as anodyne and hypnotic remedies. The water distilled from them has poisonous properties, owing to the presence of a hydrocyanated oil, which seems to be developed in a similar manner as in the case of bitter Almonds. The oil exists in largest quantity in the young leaves. *Prunus Lusitanica* is the Portugal Laurel, which is extensively cultivated in Britain as an evergreen. The leaves of *Prunus spinosa*, the Sloe, have been used as a substitute for, as well as an adulteration of Tea. The fruit of a variety of *Cerasus Avium*, the Cherry, is used in the manufacture of Kirschenwasser. The kernel of *Cerasus occidentalis* is used for flavouring Noyau. The flavour of Ratafia, Cherry-brandy, and Maraschino, is due to the kernels of *Cerasus*.

The suborder *Pomeæ* supplies many edible fruits, as Apples, Pears, Medlars (fig. 472), and Quinces. The seeds and occasionally the flowers and bark of some, yield hydrocyanic acid. All the cultivated varieties of Apple are derived by grafting from the native species, *Pyrus Malus;* while Pears have their origin in *Pyrus communis.* The seeds of *Cydonia vulgaris* (*Pyrus Cydonia*), the Quince, when boiled in water, yield a mucilaginous decoction, which has been used as a demulcent. Malic acid is found in some of the fruits of this suborder. *Eriobotrya japonica* yields the Loquat, a Japan fruit.

The other suborders contain plants which are distinguished by astringent and tonic qualities. *Geum urbanum* and *rivale* (Avens) have been employed as tonics and astringents, as also the root of *Potentilla Tormentilla* (Tormentil). *Brayera anthelmintica,* Cusso or Kousso, an Abyssinian plant, has been used as a vermifuge in cases of Tænia. The varieties of Scotch Roses are derived from *Rosa spinosissima.* The fruit of *Rosa canina,* the Dog-rose, which consists of the enlarged calyx and disk enclosing numerous achænia (fig. 270), is beat into a pulp with sugar, after the hairy achenes have been removed, and used as an acidulous refrigerant and astringent. The petals of *Rosa gallica,* Red, French, and Provins Rose, are employed in the form of infusion, as a tonic and slightly astringent remedy. The petals of *Rosa centifolia,* the Hundred-leaved or Cabbage-rose (fig. 88), and its varieties, *R. damascena,* Damask-rose, *R. moschata,* Musk-rose, &c., are employed in the preparation of Rose-water, and of the oil or attar of Roses. It is stated by Dr. Christison, that 100,000 roses, the produce of 10,000 bushes of *Rosa damascena,* yield at Ghazeepore, near Benares, only 180 grains of attar. The finest preparation of Rose as an odour is said to be prepared at Grasse in France. Oil of Roses is adulterated with sandal-wood oil. The bark of many species of *Quillaia,* as *Q. saponaria,* is used as a substitute for soap.

856. Order 71.—**Calycanthaceæ,** the Calycanthus Family. (*Polypet. Perigyn.*) Sepals and petals confounded, indefinite, combined in a fleshy tube; æstivation imbricated. Stamens ∞, perigynous; anthers adnate, extrorse, with longitudinal dehiscence. Ovaries several, 1-celled, adhering to the tube of the calyx; ovules solitary or two, one above the other, anatropal; style terminal. Fruit consisting of achænia enclosed in the fleshy tube of the calyx. Seed exalbuminous; embryo straight; cotyledons convolute; radicle inferior.—Shrubs, with square stems, consisting of a central woody mass, with four smaller ones around (¶ 90); leaves opposite, simple, scabrous, exstipulate. They are natives of North America and Japan. Their flowers are aromatic; the bark of some is used as a carminative. *Calycanthus floridus* is called Carolina or common American Allspice. The order includes 2 genera, and 6 species. *Examples*—Calycanthus, Chimonanthus.

857. Order 72.—**Lythraceæ,** the Loosetrife Family. (*Polypet. Perigyn*). Calyx tubular, lobed, the lobes sometimes with intermediate lobes or teeth; æstivation valvate. Petals alternate with the primary lobes of the calyx, very deciduous, sometimes 0. Stamens inserted

into the tube of the calyx a little below the petals, equal in number to them, or two, three, or four times as many; anthers adnate, dithecal, introrse, with longitudinal dehiscence. Ovary superior, 2-6-celled; ovules numerous, anatropal; style filiform; stigma usually capitate. Fruit a dehiscent membranous capsule, surrounded by the calyx, but not adherent to it, sometimes 1-celled by the obliteration of the dissepiments. Seeds numerous, small, apterous, or winged, exalbuminous, attached to a central placenta; embryo straight; cotyledons flat and foliaceous; radicle next the hilum.—Herbs and shrubs, with branches which are usually tetragonal, and with opposite, rarely alternate, entire, exstipulate leaves without glands. They are natives of Europe, North and South America, and India. The order is divided into two suborders:—1. Lythreæ, with apterous (wingless) seeds. 2. Lagerströmieæ, with winged seeds. Authors give 38 genera, including 316 species. *Examples*—Lythrum, Cuphea, Lagerströmia.

858. Many of the plants of the order are distinguished by astringent properties, and some are used for dyeing. *Lythrum Salicaria*, Purple Loosestrife, or Willowstrife, a European plant, found also in Australia, has been used in cases of diarrhœa, on account of the tannin in its composition. The flowers of *Grislea tomentosa* are employed in India, mixed with Morinda, for dyeing, under the name of Dhaee. *Heimia salicifolia* is said to possess diaphoretic properties, and is considered by the Mexicans as a potent remedy for venereal diseases. The Henna, or Alhenna of the Arabs, which is used in Egypt for dyeing orange, is the product of *Lawsonia inermis*. The *Cupheas* are remarkable for the mode in which the placenta bursts through the ovary and floral envelopes, so as to expose the seeds.

859. Order 73.—**Rhizophoraceæ**, the Mangrove Family. (*Polypet. Epigyn*). Calyx adherent, 4-12-lobed; æstivation valvate, or sometimes calyptriform. Petals arising from the calyx, alternate with the lobes, and equal to them in number. Stamens inserted with the petals, twice or thrice their number; filaments distinct, subulate; anthers erect. Ovary 2-3-4-celled; ovules 2 or more in each cell, anatropal. Fruit indehiscent, adherent to the calyx, and crowned by it, unilocular, monospermous. Seed solitary, pendulous, exalbuminous; cotyledons flat; radicle long, piercing the fruit.—Trees or shrubs, with simple opposite leaves, and deciduous interpetiolary stipules. They are found on the muddy shores of the tropics. There are 9 genera, and 24 species known. *Examples*—Rhizophora, Kandelia.

860. The plants of the order have frequently an astringent bark, which is in some cases used for dyeing black. *Rhizophora Mangle*, the Mangrove, forms thickets at the muddy mouths of rivers in tropical countries, and sends out adventitious roots which often raise the main trunk much above its original level, and give the tree the appearance

of being supported upon stalks. The fruit is sweet and eatable. The embryo germinates before the fruit falls, and the radicle is much elongated before the seed drops into the mud. The anther consists of numerous cells containing pollen.

861. Order 74.—**Vochysiaceæ,** the Vochysia Family. (*Polypet. Perigyn.*) Sepals 4-5, united at the base, unequal, the upper one largest and spurred; æstivation imbricated. Petals 1, 2, 3, or 5, alternate with the divisions of the calyx, and inserted into its base, unequal. Stamens 1-5, opposite to, or alternate with the petals, perigynous, one having an ovate, fertile, 4-celled anther, the rest being sterile. Ovary free, or partially adherent to the calyx, 3-celled; ovules solitary or in pairs, rarely numerous, amphitropal or anatropal; style and stigma one. Fruit a triquetrous, 3-celled and 3-valved capsule, usually with loculicidal dehiscence. Seeds usually 1-2 in each cell, erect, exalbuminous, attached to a central placenta; embryo straight; cotyledons large and leafy; radicle short and superior.—Trees or shrubs, with opposite, entire, stipulate leaves. They inhabit the warmer parts of America. Their properties are little known. Their flowers are reputed to be very sweet, and some are said to have a resinous juice. There are 8 genera enumerated, including 51 species. *Examples*—Vochysia, Qualea.

862. Order 75.—**Combretaceæ,** the Myrobalan Family. (*Polypet. Epigyn.*) Calyx 4-5-lobed, lobes deciduous. Petals arising from the orifice of the calyx, alternate with the lobes, or wanting. Stamens epigynous, twice as many as the lobes of the calyx, rarely equal in number, or thrice as many; filaments distinct, subulate; anthers dithecal, dehiscing longitudinally or by recurved valves. Ovary adherent to the tube of the calyx, unilocular; ovules 2-4, pendulous; style 1; stigma simple. Fruit succulent or nut-like, inferior, unilocular, indehiscent, often winged. Seed solitary, pendulous, exalbuminous; cotyledons leafy, usually convolute, sometimes plicate; radicle turned towards the hilum.—Trees or shrubs, with alternate or opposite exstipulate, entire leaves. They are natives of the tropical regions of Asia, Africa, and America. The general property of the order is astringency. Many are used for tanning, and some for dyeing. The fruit of *Terminalia Belerica*, and of *T. Chebula*, under the name of Myrobalans, is used as an astringent. The seeds of *Terminalia Catappa* are eaten like almonds. The order has been divided into three suborders:—1. Terminalieæ, petals 0, cotyledons convolute. 2. Combreteæ, petals present, cotyledons plicate. 3. Gyrocarpeæ, petals 0, cotyledons convolute, anthers dehiscing by recurved valves. There are 22 genera enumerated by Lindley, including 200 species. *Examples*—Terminalia, Combretum, Gyrocarpus.

863. Order 76.—**Melastomaceæ,** the Melastoma Family. (*Polypet. Perig.* or *Epigyn.*) Calyx with 4, 5, or 6 divisions, which are more

or less deep, or are sometimes united and separate from the tube like a lid. Petals equal to the segments of the calyx, perigynous, æstivation twisted. Stamens equal in number to the petals and alternate with them, usually with intermediate sterile ones; filaments curved downwards in the young state; anthers long, often beaked, bilocular, dehiscing by two terminal pores or longitudinally. Ovary more or less adherent to the calyx, multilocular; ovules usually 00; style 1; stigma simple, either capitate or minute. Fruit multilocular, either capsular, with loculicidal dehiscence, or succulent, combined with the calyx and indehiscent. Seeds ∞, minute, attached to central placentas, exalbuminous; embryo straight or curved; cotyledons sometimes unequal, flat, or convolute.—Trees, shrubs, or herbs, with opposite, undivided, usually entire, often 3-9-ribbed leaves, not dotted. They are found chiefly in warm climates. Many are natives of America and India. There are no unwholesome plants in the order, and the succulent fruit of several is edible. A slight degree of astringency pervades all the plants of the order, and hence some are used medicinally in cases of diarrhœa. The name *Melastoma* (μέλας, black, and στόμα, mouth), is derived from the circumstance that the fruit of some dyes the lips black. There are two suborders:—1. Melastomeæ, with ribbed leaves and flat cotyledons. 2. Memecyleæ, with ribless leaves and convolute cotyledons. Authors notice 165 genera, comprising 2000 species. *Examples*—Melastoma, Osbeckia, Lasiandra, Rhexia, Lavoisiera, Miconia, Charianthus, Memecylon, Mouriria.

864. Order 77.—**Alangiaceæ**, the Alangium Family. (*Polypet. Epigyn.*) Calyx campanulate, adherent, 5-10-toothed. Petals 5-10, linear, reflexed, inserted into a fleshy disk, which is adherent to the calyx, and ovary; æstivation twisted. Stamens long, exserted, 2 or 4 times as many as the petals; filaments distinct, villous at the base; anthers bilocular, adnate, introrse, often sterile. Ovary globose, uni-bilocular; ovules solitary, anatropal; style filiform; stigma capitate or conical. Fruit oval, fleshy, coherent with the tube of the calyx, and somewhat crowned by its limb, slightly ribbed; endocarp sometimes osseous, with a foramen at the apex. Seed solitary, anatropal, albumen fleshy, brittle; embryo straight; cotyledons flat, foliaceous; radicle long, superior.—Trees or shrubs, with alternate, exstipulate leaves, which are not dotted. They are found chiefly in India, some are natives of America; some of the plants yield edible fruits, others are purgative. Authors enumerate 5 genera, comprehending 10 species. *Examples*—Alangium, Nyssa.

865. Order 78.—**Philadelphaceæ**, the Syringa Family. (*Polypet. Epigyn.*) Calyx with a 4-10-divided, persistent limb. Petals alternate with the divisions of the calyx, and equal to them in number; æstivation convolute, imbricate. Stamens ∞ (rarely 10), in one or two rows, arising from the orifice of the calyx. Ovary adherent to

the tube of the calyx; styles distinct, or united into one; stigmas 4-10; ovules ∞, attached to a central placenta. Fruit a 4-10-celled capsule, free above. Seeds ∞, scobiform, subulate, smooth, pendulous, with a loose membranous arillus; albumen fleshy; embryo straight, about as long as the albumen; cotyledons flat; radicle next the hilum, obtuse.—Shrubs with deciduous, opposite, exstipulate leaves without dots; flowers usually in trichotomous cymes. They are natives of the South of Europe, of North America, Japan, and India. They have no marked properties. The flowers of *Philadelphus coronarius*, Syringa, have a peculiar sweetish odour, which to some persons is overpowering and disagreeable. The smell is due to the presence of an oil. *Deutzia scabra* has a scurfy matter on its leaves, which, under the microscope, is seen to consist of beautiful stellate hairs. The leaves are in consequence used in Japan by polishers. Its inner bark is used for poultices. There are 5 genera enumerated, including 27 species. *Examples*—Philadelphus, Deutzia, Decumaria.

866. Order 79.—**Myrtaceæ**, the Myrtle Family. (*Polypet. Epigyn.*) Calyx 4-5-6-8-cleft, the limb sometimes cohering at the apex, and falling off like a lid; æstivation valvate. Petals attached to the calyx, alternating with its segments, and equal to them in number, with a quincuncial æstivation, rarely 0. Stamens inserted with the petals, twice as many as the petals, or ∞; filaments distinct, or united in one or more parcels, curved inwards in the bud; anthers ovate, dithecal, with longitudinal dehiscence. Ovary adherent to the tube of the calyx, 1-6-celled; style and stigma simple; ovules anatropal, pendulous or erect. Fruit dry or fleshy, dehiscent or indehiscent. Seeds usually ∞, attached to a central placenta; mostly exalbuminous; embryo straight or curved; cotyledons distinct (fig. 514), or consolidated with the radicle, which is next the hilum.—Trees or shrubs, with opposite, rarely alternate leaves, which are usually entire and dotted, and frequently have an intramarginal vein. They are natives chiefly of warm countries, as South America and the East Indies. Many, however, are found in more temperate regions. Some of the genera are peculiar to Australia. The order has been divided into the following suborders:—1. Chamælaucieæ, heath-like plants with a 1-celled ovary and capsule, and opposite dotted leaves. 2. Leptospermeæ, having a multilocular capsule, and opposite or alternate, usually dotted leaves. 3. Myrteæ, having a baccate fruit, distinct stamens, opposite dotted leaves. 4. Barringtonieæ, having a fleshy 1-celled fruit, monadelphous stamens, albuminous seeds, opposite or verticillate leaves, not dotted. 5. Lecythideæ, having a multilocular woody capsule, which either remains closed or opens by a lid, monadelphous stamens, alternate, not dotted leaves. Several of these suborders are made separate orders by Lindley and others. There are 99 known genera, and upwards of 1500 species. *Examples*—Chamælaucium,

Calytrix, Leptospermum, Melaleuca, Metrosideros, Eucalyptus, Myrtus, Psidium, Eugenia, Caryophyllus, Barringtonia, Gustavia, Lecythis, Bertholletia.

867. Many of the plants of the order yield an aromatic volatile oil. This is particularly the case with those having pellucid dots in their leaves. Many yield edible fruits, others furnish astringent and saccharine substances. The leaves of some species of *Leptospermum* and *Melaleuca* are used as tea in Australia. The leaves of *Melaleuca minor* (*Cajuputi* of some), a native of the Moluccas, yield the volatile oil of Cajeput. It is a very liquid oil, of a grass-green colour, having a pungent camphoraceous odour, and capable of dissolving caoutchouc. It is used medicinally as a stimulant and antispasmodic. Species of *Eucalyptus* constitute the gigantic gum-trees of Australia, some of which attain a height of two hundred feet. They are remarkable for their operculate calyx, which may be considered as formed by several jointed leaves (like those of the orange), united throughout, and separating at the articulation in the form of a lid (¶ 366). Their bark also separates remarkably in layers. They yield an astringent matter, which has been used for tanning. *Eucalyptus resinifera*, Brown Gum-tree of New Holland, furnishes Botany-Bay Kino, an astringent resinous-like substance, which exudes in the form of red juice from incisions in the bark. A single tree will yield sixty gallons. *E. mannifera* gives a saccharine exudation resembling manna. A saccharine substance, mixed with cellular hairs, which arise from a cup-like body, has been sent to this country by Mr. Cay, found upon the leaves of *E. dumosa*. It is called Lurp by the natives, and is produced by the attack of a species of insect belonging to the genus Psylla. The wood of many species of *Metrosideros* is hard and dark-coloured. The flower-buds of *Caryophyllus aromaticus* (*Eugenia caryophyllata*), a tree which was originally a native of the Moluccas, but is now cultivated in the East and West Indies, constitute the Cloves of commerce. They have the form of a nail, and, when examined, are seen to consist of the tubular calyx with a roundish projection formed by the unopened petals. They contain a volatile oil, associated with resinous, gummy, and astringent matter. The oil is aromatic and acrid, and has been used as a condiment and a stimulant carminative. Pimento, Allspice, or Jamaica Pepper, is the berried fruit of *Eugenia Pimenta* (*Myrtus Pimenta*), a tree which is a native of the West Indies and Mexico. The fruit has an aromatic odour, and its taste combines that of cinnamon, nutmeg, and cloves; hence the name Allspice. It contains an acrid volatile oil, to which its properties are due. Medicinally Pimento is sometimes employed as a stimulant and carminative. The fruit of *Eugenia acris* is used for Pimento. Among the pulpy edible fruits of the order may be noticed Guavas and Rose-apples. The former are the produce of various species of *Psidium*, such as *P.*

pyriferum, *pomiferum*, and *Cattleyanum*; the latter are procured from species of *Eugenia*, as *E. Jambos*, and *Malaccensis*. The berries of the common Myrtle (*Myrtus communis*) are also used as food. *Punica Granatum*, the Pomegranate-tree, is a native of the warmer parts of Asia and Northern Africa, whence it was introduced into Europe. It is the רמן of Scripture. It produces dark scarlet flowers, formerly called Balaustia, which have been used as an astringent. The fruit of the Pomegranate has given rise to much difference of opinion among botanists. It is composed, in the young state, of two rows of carpels, some of which are placed round the axis, and adhering to the bottom of the calycine tube, while others are placed outside, and adhere to the upper part of the tube. The subsequent contraction of the tube of the calyx, and the peculiar adhesion of the placentas, according to Lindley, account for the anomaly in the fruit (Balausta, ¶ 550). The rind of the fruit (malicorium), and the bark of the root, are used as anthelmintics, especially in cases of tape-worm. *Lecythis ollaria*, a large Brazilian tree, yields the woody capsules called Monkey-pots, which open by circumscissile dehiscence. These seed-vessels seem to be formed in the same way as the calyx of Eucalyptus, the part where the lid separates indicating the articulations of the carpellary leaves. The seeds are eatable, and are relished by monkeys. The bark of the tree may be separated into numerous thin layers. *Bertholletia excelsa* is the source of the Brazil nuts.

868. Order 80.—**Onagraceæ**, the Evening-Primrose Family. (*Polypet. Epigyn.*) Calyx tubular, the limb having usually 4 (fig. 399 *l*), sometimes 2, 3, or 6 divisions (fig. 531), which cohere in various ways; æstivation valvate. Petals usually equal in number to the calycine segments, regular (rarely irregular), inserted into the tube of the calyx (fig. 399 *p*); æstivation twisted. Stamens usually 4 or 8 (rarely 1 or 2, fig. 531), epigynous (fig. 399 *e*); filaments distinct; pollen triangular, usually cohering by threads. Ovary 2-4-celled (figs. 384, 531), adherent (fig. 399 *o*), usually with an epigynous disk; style filiform; stigma capitate (fig. 399 *s*) or 4-lobed; ovules (figs. 384 *o*, 399 *g*) indefinite, rarely definite, anatropal. Fruit succulent or capsular, dehiscent or indehiscent, 1-2-4-celled. Seeds usually ∞, exalbuminous; embryo straight, with a long slender radicle pointing to the hilum, and short cotyledons.—Herbs or shrubs, with alternate or opposite, simple, not dotted leaves, and with the parts of the flower usually tetramerous. They inhabit chiefly temperate regions, and are found abundantly in Europe, Asia, and America, and sparingly in Africa. Some yield edible fruits, as *Fuchsia*, others furnish edible roots, as *Œnothera biennis*. Many of them have mucilaginous properties, while a few are astringent. *Trapa* has unequal cotyledons. *T. natans*, Water Chestnut, and *T. bicornis*, remarkable for its horned fruit, both supply edible seeds. There are about 30 known genera,

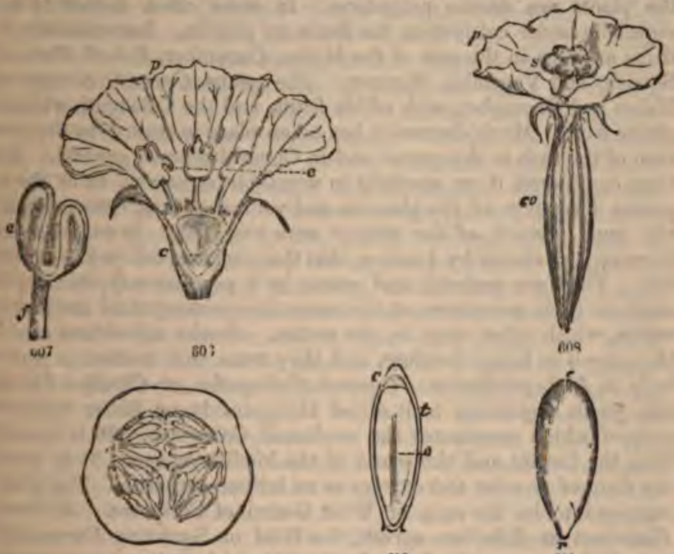
and upwards of 450 species. *Examples*—Œnothera, Epilobium, Jussiæa, Montinia, Fuchsia, Circæa, Gaura, Trapa.

869. Order 81.—**Halorageaceæ,** the Mare's-Tail Family. (*Polypet. Epigyn.*) Calyx with a minute limb, which is either 3-4-divided or entire; it is sometimes reduced to a mere rim. Petals epigynous or 0. Stamens epigynous, equal in number to the petals, or twice as many, rarely fewer; when the petals are wanting, stamens often 1 or 2. Ovary cohering with the tube of the calyx, with 1 or more cells, sometimes tetragonal or compressed. Style 0, what is frequently called the styles being the papulose stigmas, which are equal in number to the cells; ovules pendulous, anatropal. Fruit dry, indehiscent, membranous or bony, with 1 or more cells. Seed solitary or in pairs, pendulous; albumen fleshy or thin; embryo straight, or slightly curved, in the axis of the albumen; cotyledons minute; radicle superior, long.—Herbs or undershrubs, often aquatic, with large air cavities, having alternate, opposite, or whorled leaves, and axillary, sessile flowers, which are occasionally unisexual. They are found in ditches and lakes in various parts of the world. They have no properties of importance. There are 10 known genera, and about 80 species. *Examples*—Hippuris, Myriophyllum, Haloragis, Callitriche.

870. Order 82.—**Loasaceæ,** the Chili-Nettle Family. (*Polypet. Epigyn*). Calyx 4-5-parted, persistent, spreading in æstivation. Petals 5, cucullate, epigynous, alternate with the segments of the calyx, sometimes with an inner row of 5, which are either similar to the outer or dissimilar; æstivation inflexed, valvate, or twisted. Stamens ∞, in several rows, distinct, or polyadelphous, each parcel being opposite the outer petals; filaments subulate, unequal, the outer ones often sterile. Ovary inferior, 1-celled, with parietal placentas; ovules anatropal; styles combined into 1; stigma 1 or several. Fruit capsular or succulent, 1-celled. Seeds without an arillus; embryo straight, in the axis of fleshy albumen; cotyledons small, flat; embryo pointing to the hilum.—Herbaceous plants, hispid with stinging hairs, having opposite or alternate exstipulate leaves, and axillary 1-flowered peduncles. They are American plants, chiefly distinguished for their stinging qualities, and hence the name of Chili-Nettle. The roots of *Mentzelia hispida*, a Mexican herb, are said to possess purgative qualities. There are 19 genera enumerated by authors, including 75 species. *Examples*—Loasa, Mentzelia, Gronovia.

871. Order 83.—**Cucurbitaceæ,** the Cucumber Family. (*Polypet.* or *Monopet. Epigyn.* and *Diclines.*) Calyx 5-toothed (figs. 396 *l*, 606 *c*) sometimes obsolete. Petals 5, distinct, or more or less united, sometimes scarcely distinguishable from the calyx, strongly marked with reticulated veins (figs. 396 *p*, 606 *p*), sometimes fringed. Stamens 5, distinct or united in one or three parcels, attached to the petals (fig. 606 *e*); anthers bilocular, sinuous (figs. 332, 607, *a*); ovary (figs.

396 *o*, 608 *c o*) adhering to the tube of the calyx, 1-celled, formed by 3 carpels, and having 3 parietal placentas (fig. 609), which sometimes project so as to join in the centre, the ovules remaining attached to the curved free edges; ovules solitary or indefinite (fig. 609), anatropal; styles short; stigmas very thick, velvety or fringed (fig. 608 *s*).



Fruit a pepo (¶ 551). Seeds flat and ovate (fig 610), enveloped in a juicy or dry and membranous covering; testa coriaceous; albumen 0; embryo straight (figs. 610 *e*, 611); cotyledons leafy and veined; radicle next the hilum.—Herbaceous plants, with succulent stems, climbing by means of lateral tendrils, which are transformed stipules; leaves alternate and palmate, covered with asperities; flowers generally unisexual. They are natives of warm climates chiefly, and abound in India. A few are found to the north in Europe and North America, and several are natives of the Cape of Good Hope. Those which are annuals readily submit to the climate of northern latitudes during the

Figs. 606-611.—Organs of fructification of Cucurbitaceæ.

Fig. 606.—Male flower of Cucumis sativus, Common Cucumber, laid open to show the interior of it. *c*, 5-divided calyx. *p*, United petals, by some considered as being an internal coloured calyx. *e*, Epigynous stamens.

Fig. 607.—Stamens separated. *f*, Filament. *a*, Long sinuous anther.

Fig. 608.—Female flower. *c o*, Calyx adherent to the ovary. *p*, United petals. *s*, Thick velvety stigmas.

Fig. 609.—Horizontal section of the ovary, showing its division into three, by projections from the parietal placentas, to which the indefinite ovules are attached.

Fig. 610.—Anatropal seed cut vertically. *t*, Spermoderm swollen at the chalaza, *c*. *e*, Embryo.

Fig. 611.—Embryo separated. *r*, Radicle. *c*, Cotyledons.

summer, and thus though of tropical origin, they grow well in European gardens. There are nearly 66 known genera, and about 330 species. *Examples*—Cucurbita, Cucumis, Momordica, Bryonia, Telfairia.

872. A certain degree of acridity pervades the order, and many of the plants are drastic purgatives. In some cases, however, more especially under cultivation, the fruits are eatable. Instances of edible fruits are seen in the case of the Melon, Cucumber, Gourd, Pumpkin, Squash, and Vegetable Marrow. The genus *Cucumis* contains the Melon and Cucumber, with edible fruits, and the Colocynth with purgative fruit. Much discussion has taken place in regard to the structure of the fruit in this genus, and in Cucurbitaceæ in general. Some have considered it an anomaly in vegetable structure, from the apparent formation of the placenta and ventral suture, externally, as if the usual position of the carpels were reversed. It would appear, however, as shown by Lindley, that the placentas follow the ordinary law. They are parietal, and curve in a peculiar way, bearing the seeds on their curvature; at the same time prolongations are sent inwards, which often meet in the centre. Stocks and others consider the carpels as being involute, and they trace this involution particularly in *Luffa pentandra*. *Cucumis Colocynthis*, or *Citrullus Colocynthis*, yields a globular fruit called Coloquintida, or Bitter Apple, the pulp of which constitutes the medicinal Colocynth. It is imported from the Levant and the coasts of the Mediterranean. It is used in the form of powder and extract as an irritant cathartic. The plant is supposed to be the פקעת, or Wild Gourd of Scripture. *Momordica Elaterium* or *Ecbalium agreste*, the Wild or Squirting Cucumber, is so called on account of the force with which its seeds are expelled when ripe. The fruit, by a process of endosmose going on in the cells, becomes distended, and ultimately gives way at the weakest part, where the peduncle is united to it. In separating from the stalk, the elasticity of the parietes comes into play, so as to discharge the brown seeds and slimy juice through the aperture at the base of the fruit. The feculence which subsides from the juice constitutes the medicinal Elaterium, which is used in small doses of $\frac{1}{8}$—$\frac{1}{2}$ a grain, as a violent cathartic, especially in dropsical cases. The active principle is Elaterin. The roots of *Bryonia alba* and *dioica* are also powerful purgatives. The fruit of various species of Gourd, as *Cucurbita Pepo*, the White Gourd, and *C. maxima* the Red Gourd, *C. ovifera*, the Vegetable Marrow, are used as potherbs; while *C. Citrullus*, the Water Melon, is prized for its cool refreshing juice. The fruit of *Lagenaria vulgaris*, in consequence of having a hard outer covering, is used as a vessel for containing fluid, after the pulp and seeds are removed. It is hence called Bottle Gourd. It is stated that poisoning has followed on the drinking of beer that had been standing in a flask made of one

those Gourds. Dr. Royle mentions that symptoms of cholera have en induced by eating the bitter pulp. The seeds of the plants in s order frequently supply a bland oil. The seeds of *Telfairia pedata* as large as Chestnuts, and are used as food.

873. Order 84.—**Papayaceæ,** the Papaw Family. (*Monopet. lypet. Epigyn.* and *Diclines.*) Calyx minute, 5-toothed. Corolla nopetalous, inserted into the base of the calyx: in the male, bular and 5-lobed; in the female, divided nearly to the base into 5 gments. In the section Pangieæ the sepals and petals are distinct. amens 10, inserted into the throat of the corolla; anthers bilocular, trorse, innate, dehiscing longitudinally. Ovary free, 1-celled; ules indefinite, attached to 5 parietal placentas; stigma 5-lobed, cerated. Fruit usually succulent and indehiscent, sometimes capular and dehiscent, 1-celled. Seeds ∞, enveloped in a loose mucous at, parietal; spermoderm brittle, pitted; embryo in the axis of eshy albumen; cotyledons flat; radicle slender, turned towards the ilum.—Trees or shrubs, not branching, with alternate lobed leaves, upported on long slender petioles, and with unisexual flowers. They re found in South America, and in other warm countries. One of he most important plants of the order is *Carica Papaya*, the Papawree, which yields an acrid milky juice, and an edible fruit. The juice the unripe fruit and the seeds are said to act as anthelmintics. is tree is said to have the property of rendering meat tender. The ds of *Trichadenia zeylanica*, a large tree of Ceylon, called Tettigaha Tettigass, yield an oil used for burning. The oil expressed from the ls of *Chaulmoogra odorata* is used in India for the cure of leprosy for various cutaneous diseases. The tree is poisonous, but the yield by expression a bland fixed oil having a peculiar smell aste. The surface of the leprous ulcers is dressed with the oil, a six-grain pill of the seed is given three times a day. The of *Hydnocarpus venenatus* and *H. Toon* is used to poison fish. rder has been divided into three sections:—1. Cariceæ, corolla etalous, fruit succulent and indehiscent. 2. Modecceæ, corolla etalous, fruit capsular and dehiscent. 3. Pangieæ, corolla alous. There are 13 known genera, including 34 species. *es*—Carica, Modecca, Pangium.

Order 85.—**Belvisiaceæ,** the Belvisia Family. (*Monopet.* Calyx gamosepalous, persistent, limb divided into 5 thick ments; æstivation valvate. Petals inserted in the tube of the ited more or less, and forming 3 verticils, the innermost of ay be considered as an altered staminal row; the outer erticil consists of 5 plaited lobes, each of which is 7-toothed, 7 feathered ribs; the second petaline verticil is cut into a narrow segments; while the third is an inconspicuous cupwith its edge minutely divided. Stamens ∞, united at their base so as to be monadelphous, or unequally polyadelphous; filaments curved inwards; anthers dithecal, oblong. Ovary surrounded by a fleshy disk, and adherent to the tube of the calyx, 5-celled; ovules 2 in each cell, attached to a central placenta, nucleus curved; style 5-angled; stigma broad, flat, pentagonal. Fruit a large fleshy rounded berry, crowned by the lobes of the calyx. Seeds large, kidney-shaped; cotyledons plano-convex; radicle and plumule immersed in their substance.—Shrubs, with alternate, simple, coriaceous, exstipulate leaves; and axillary flowers often in sets of three. They are tropical, chiefly African. The pulp of the fruit is eatable. The rind contains much tannin, and has been used for making ink. The wood is soft, and presents numerous dotted vessels. Their place in the natural system is not well determined; some placing the order next Passifloraceæ, others near Symplocaceæ, and Lindley recognizing its affinity to Rhizophoraceæ. There are 2 genera and 4 species. *Examples*—Belvisia (Napoleona), Asteranthus.

875. Order 86.—**Passifloraceæ**, the Passion-flower Family. (*Polypet. Perigyn.*) Sepals 5, combined below into a more or less elongated tube. Petals 5, perigynous, often with filamentous or annular processes on their inside, which appear to be an altered whorl or whorls of petals, occasionally wanting, imbricated in æstivation. Stamens 5, monadelphous, surrounding the gynophore when present, rarely ∞, usually with processes from the thalamus, interposed between them and the petals; anthers dithecal, extrorse, versatile, dehiscing longitudinally; pollen-grains sometimes bursting by opercula (fig. 354). Ovary 1-celled, often with a gynophore (¶ 437); ovules anatropal, ∞; styles 3; stigmas dilated. Fruit often stipitate, 1-celled, sometimes 3-valved, opening by loculicidal dehiscence, or succulent and indehiscent. Seeds ∞, attached to parietal placentas, arillate, or strophiolate; spermoderm brittle and sculptured; embryo straight in the midst of thin fleshy albumen; radicle pointing to the hilum.—Herbs or shrubs, often climbing, with alternate, stipulate, or exstipulate leaves. The order has been divided into three suborders:—1. Paropsieæ, plants not climbing, with a sessile ovary, arillate seeds, and exstipulate leaves. 2. Passifloreæ, climbing plants with a stalked ovary, arillate seeds, stipulate leaves, and glandular petioles. 3. Malesherbieæ, plants not climbing, with a stalked ovary, style below the apex of the ovary, strophiolate seeds, and exstipulate leaves. They are natives chiefly of warm climates, and are found in America, the East and West Indies. There are 14 known genera, and 223 species. *Examples*—Paropsis, Smeathmannia, Passiflora, Tacsonia, Malesherbia.

876. Considerable discussion has taken place as to the true nature of the calyx and corolla in Passifloraceæ Lindley supports the view here given. Others consider the calyx as consisting of ten sepals in two rows, the inner more or less petaloid, and they look on the petals

as either wanting, or existing in the form of filamentous or annular processes. The name Passion-flower was given on account of a fancied resemblance in the flowers to the appearances presented at Calvary. In the five anthers the superstitious monks saw a resemblance to the wounds of Christ; in the triple style, the three nails on the cross; in the central gynophore, the pillar of the cross; and in the filamentous processes, the rays of light round the Saviour, or the crown of thorns. Many of the plants, such as *Passiflora quadrangularis* and *edulis*, Grenadillas, yield edible fruits, the pulp or succulent arillus being fragrant and cooling. The root of *Passiflora quadrangularis* is said to be emetic and powerfully narcotic, on which account it is said to be cultivated in several French settlements. It is said to owe its activity to a peculiar principle called Passiflorine. Other plants of the order are bitter and astringent.

877. Order 87.—**Turneraceæ,** the Turnera Family. (*Polypet. Perigyn.*) Calyx with 5 equal lobes; æstivation imbricated. Petals 5, perigynous, equal; æstivation twisted. Stamens 5, perigynous, alternating with the petals; filaments distinct; anthers dithecal, innate, oblong. Ovary free, 1-celled, with 3 parietal placentas; ovules ∞, anatropal; styles more or less cohering, or forked; stigmas multifid. Fruit a 1-celled, 3-valved capsule, dehiscing only half-way down, in a loculicidal manner. Seeds crustaceous, reticulated, arillate on one side; embryo slightly curved, in the midst of fleshy albumen; cotyledons plano-convex; radicle pointing to the hilum.—Herbaceous or somewhat shrubby plants, occasionally with stellate pubescence, having alternate, exstipulate leaves, and frequently two glands at the apex of the petiole. They are natives of the West Indies and South America. They are not put to any important use. *Turnera opifera* is astringent, and is employed in Brazil against dyspepsia. *Turnera ulmifolia* is considered tonic and expectorant. Lindley gives 2 genera, including 60 species. *Examples*—Turnera, Piriqueta.

878. Order 88.—**Portulacaceæ,** the Purslane Family. (*Polypet. Perigyn.*) Sepals 2, cohering at the base. Petals usually 5, rarely wanting, distinct or cohering at the base, sometimes hypogynous. Stamens usually perigynous, variable in number, all fertile, sometimes opposite the petals; filaments distinct; anthers versatile, bilocular, with longitudinal dehiscence. Ovary free or partially adherent, 1-celled, formed by 3 united carpels; style single or 0; stigmas several. Fruit capsular, 1-celled, opening by circumscissile dehiscence, or by 3 valves, occasionally monospermous and indehiscent. Seeds numerous or definite, or solitary, attached to a central placenta; albumen farinaceous; embryo peripherical; radicle long.—Succulent shrubs or herbs, with alternate, seldom opposite, entire, exstipulate leaves, often having hairs in their axils. They are found in various parts of the world, chiefly, however, in South America and at the Cape of Good

Hope. They always inhabit dry parched places. They have a great affinity to Caryophyllaceæ, from which they are chiefly distinguished by their bisepalous calyx, perigynous stamens, and transversely dehiscent capsule. Lindley places this and the succeeding order among hypogynous Exogens, next to Caryophyllaceæ. The plants belonging to the order have few properties of importance. They are insipid and destitute of odour. *Portulaca oleracea*, common Purslane, is used as a potherb on account of its cooling and antiscorbutic qualities; the ancients thought the seeds, steeped in wine, to be an emmenagogue. The tuberous roots of *Claytonia tuberosa*, a Siberian plant, are eaten; and those of *Melloca* (*Ullucus*) *tuberosa*, a native of Peru, have been recommended as a substitute for the potato. There are 18 known genera, and 196 species. *Examples*—Portulaca, Talinum, Calandrinia, Claytonia, Montia.

879. Order 89.—**Paronychiaceæ**, the Knotwort Family. (*Polypet. Perigyn.*) Sepals 4-5, distinct or cohering. Petals perigynous, between the divisions of the calyx, usually inconspicuous, sometimes 0. Stamens usually perigynous, sometimes hypogynous, opposite to the sepals when equal to them in number, some of them occasionally wanting; filaments distinct, rarely united; anthers bilocular. Ovary superior, with one or more ovules; styles 2-3, distinct or combined. Fruit unilocular, either a utricle covered by the calyx, or a 3-valved capsule. Seeds either numerous, attached to a free central placenta, or solitary and pendulous from a long funiculus arising from the base of the fruit. Embryo more or less curved, lying on one side of the farinaceous albumen, or surrounding it.—Herbaceous or somewhat shrubby plants, with opposite or alternate, sometimes setaceous and clustered leaves, which are either exstipulate or have scarious stipules. Found in barren places in various parts of Europe, Asia, and North America. A slight degree of astringency pervades this order, and is the only sensible property that it is known to possess. The order has been divided into two sections:—1. Illecebreæ, with the embryo lying on one side of the albumen, and stipulate leaves. 2. Sclerantheæ, with a peripherical embryo, and exstipulate leaves. There are 31 known genera, and nearly 125 species. *Examples*—Paronychia, Illecebrum, Polycarpon, Corrigiola, Scleranthus.

880. Order 90.—**Crassulaceæ**, the Houseleek Family (figs. 535, 536). (*Polypet. Perigyn.*) Sepals 3-20, more or less united at the base (fig. 258 *c c*). Petals equal to the sepals in number, inserted in the bottom of the calyx (fig. 258 *p p*), either distinct or cohering in a gamopetalous corolla. Stamens inserted with the petals, either equal to them in number, and alternate with them (fig. 258 *e e*), or twice as many, those opposite the petals being shortest; sometimes one or two rows of abortive stamens; filaments distinct, or united, subulate, anthers bilocular, dehiscing longitudinally or transversely. Abortive

stamens or scales (sometimes obsolete), at the base of each carpel (fig. 258 *a a*). Carpels equal in number to the petals and opposite to them, 1-celled (fig. 258 *o o*), sometimes consolidated; styles several or combined; stigmas pointed or 4-cornered; ovules 00, or definite, anatropal. Fruit consisting of several follicles, dehiscing by the ventral suture, sometimes by the dorsal suture. Seeds variable in number; embryo straight, in the midst of fleshy albumen; radicle pointing to the hilum.—Herbaceous plants or shrubs, often succulent, with simple, entire, or pinnatifid, exstipulate leaves. They are found in the driest situations, as on rocks, walls, and sandy plains, in various parts of the world. Some of them are acrid, as *Sedum acre*, Biting Stonecrop; others are refrigerant, from the presence of an acid, such as malic acid. *Sempervivum tectorum* is commonly known as the Houseleek. The fishermen of Madeira rub their nets with the fresh leaves of the *Sempervivum glutinosum*, by which the nets are rendered as durable as if tanned, provided they are steeped in some alkaline liquor. *Bryophyllum calycinum* is remarkable for the property of producing germinating buds at the edges of its leaves (¶ 199). There are two suborders:—1. Semperviveæ, with carpellary scales, numerous separate carpels in the pistil. 2. Galacieæ or Francoeæ, without true scales, pistil consolidated. There are 28 genera, and about 485 species. *Examples*—Crassula, Sempervivum, Cotyledon, Sedum, Penthorum, Galax, Francoa.

881. Order 91.—**Ficoideæ**, or **Mesembryaceæ**, the Ficoid or Mesembryanthemum Family. (*Polypet. Perigyn.*) Sepals definite, usually 5, but varying from 4-8, more or less combined at the base, adherent to the ovary or distinct from it, equal or unequal; æstivation valvate or imbricate. Petals indefinite, coloured, sometimes 0. Stamens perigynous, distinct, definite or indefinite; anthers oblong, incumbent. Ovary usually many-celled; stigmas several, distinct; ovules 00, anatropal or amphitropal, attached by cords to the placenta, which is either central or parietal. Fruit a many-celled capsule, opening in a stellate or circumscissile manner at the apex, or an indehiscent nut. Seeds 00, rarely definite or even solitary; embryo curved or spiral on the outside of mealy albumen; radicle next the hilum.—Herbaceous or shrubby succulent plants, with opposite or alternate simple leaves. They are found in warm regions chiefly. The greater part of them grow at the Cape of Good Hope. The order has been divided into three sections:—1. Mesembryeæ, numerous conspicuous petals, many-celled capsule, with stellate dehiscence. 2. Tetragonieæ, petals 0, fruit woody and indehiscent. 3. Sesuveæ, petals 0, capsule with circumscissile dehiscence. There are 16 known genera, and 440 species. *Examples*—Mesembryanthemum, Tetragonia, Aizoon, Sesuvium.

Some of them are used as articles of diet, as the leaves of *Mesembryanthemum edule*, Hottentot's Fig, and *Tetragonia expansa*, New

Zealand Spinach. Others yield soda, and have been employed in the manufacture of glass. *Mesembryanthemum crystallinum*, the Ice-plant, is remarkable for the watery vesicles which cover its surface, and which have the appearance of pieces of ice. Its juice is said to be diuretic, and has been prescribed in dropsy and liver complaints. The seed-vessels of some species of *Mesembryanthemum*, as *M. Tripolium*, have the property of expanding in a star-like manner when put into water, and closing when dry. The flowers of many of the plants of the order exhibit the phenomenon of opening only under the influence of sunshine and closing in dull weather (¶ 483).

882. Order 92.—**Cactaceæ**, the Cactus or Indian Fig Family. (*Polypet. Epigyn.*) Sepals numerous, usually ∞, and confounded with the petals, adherent to the ovary. Petals numerous, usually indefinite, sometimes irregular, inserted at the orifice of the calyx. Stamens indefinite, cohering more or less with the petals and sepals; filaments long, filiform; anthers ovate, versatile. Ovary fleshy, inferior, unilocular; style filiform; stigmas numerous; ovules ∞, attached to parietal placentas equal in number to the stigmas. Fruit succulent, 1-celled. Seeds ∞, parietal, or, after losing their adhesion to the placenta, nestling in pulp, ovate or obovate; albumen 0; embryo straight, curved or spiral; cotyledons thick, leafy, sometimes nearly obsolete; radicle thick, obtuse, next the hilum.—Succulent shrubs, with peculiar angular or flattened stems, having the woody matter often arranged in wedges. Leaves usually absent; when present, fleshy, smooth, entire, or spinous. Flower sessile, sometimes showy. They grow in hot, dry, and exposed places, and are natives chiefly of the tropical parts of America. Some grow rapidly on the lava in volcanic countries. There are 18 known genera, and about 860 species. *Examples*—Opuntia, Melocactus, Mammillaria, Echinocactus, Cereus, Epiphyllum, Pereskia, Rhipsalis.

883. The plants of this order are remarkable for their succulence, for the great development of their cellular tissue, and the anomalous forms of their stems, some of which attain a great size. In their structure numerous spiral cells are met with, and in many cases the fibre in these cells is interrupted so as to present thickened rings united by membrane. These rings, when the cells are macerated, can be obtained in a free state. Many of the plants in this order show a remarkable tendency to spiral development. The setæ, spines, and hairs, are sometimes arranged spirally, and in *Cereus flagelliformis* the cells of the setæ have this tendency. Many of them yield an edible fruit, which is sometimes refreshing and agreeable, at other times insipid. The fruit of *Pereskia aculeata*, under the name of Barbadoes Gooseberry, is used in the West Indies as an article of diet. That of *Opuntia vulgaris* is known under the name of Prickly Pear. The juice of the fruit of some species is subacid, and has sometimes been used as a refrigerant

Cattle sometimes feed on the succulent stems in dry seasons. Some of the plants are noted as night-flowering (¶ 484). *Cereus grandiflorus* expands its large white blossoms about 10 P.M. in our hothouses, and their beauty lasts only for the night. Such is also the case with *Cereus nycticalus.* A plant of the latter species, in the Glasgow Botanic Garden, began to open its flowers between 7 and 8 P.M., and they were fully opened at 10. The following were the numbers and sizes of the various parts:—

Length of the tube of the calyx	7 inches
Length of the petals	4½ —
Length of the style	10 —
Breadth of flower when fully expanded	11 —
Number of long sepals	75
Number of short sepals	20
Number of petals	25
Number of stamens	400
Number of stigmas	15

The size to which some of the Cactus family grow may be illustrated by a specimen of *Echinocactus Viznaga*, imported into Kew gardens from the mountains of San Luis, Potosi:—

Weight of the plant	713 lbs.
Height from surface of the earth	4½ feet.
Measured over the top from the ground on each side	10 feet 9 inches.
Circumference at 1 foot from the ground	8 feet 7 inches.
Number of deep angles or costæ	44
Number of spines	8800

In Brazil, some epiphytic Cactuses are met with; and there are some species described by Gardner as attaining a height of thirty feet, with a circumference of three feet. *Opuntia cochinellifera*, and other species, are infested by the Coccus Cacti, or the cochineal insect, which feeds upon them. The plants are cultivated in what are called nopaleries, for the sake of the insect, the females of which, when dried, constitute the cochineal of commerce.

884. Order 93.—**Grossulariaceæ**, the Gooseberry and Currant Family. (*Polypet. Epigyn.*) Calyx 4-5-cleft, regular, coloured. Petals minute, perigynous, equal in number to the segments of the calyx, and alternate with them. Stamens 4-5, alternate with the petals, and inserted into the throat of the calyx; filaments short; anthers dithecal. Ovary unilocular, adherent to the tube of the calyx; ovules ∞, anatropal, attached to two opposite parietal placentas; style single, 2-4-cleft. Fruit a 1-celled berry, crowned with the remains of the flower. Seeds ∞, immersed in pulp, and attached to the placentas by long thread-like funiculi; spermoderm gelatinous externally; albumen horny; embryo straight, minute; radicle pointing to the hilum.—Shrubs, with alternate lobed leaves, having a

plicate vernation. They are natives of temperate regions, and are found in Europe, Asia, and America. Many yield edible fruits, which sometimes contain malic acid. The various kinds of Gooseberry (*Ribes Grossularia*), and Currant (*Ribes rubrum* and *nigrum*) belong to this order. The black currant possesses tonic and stimulant properties. On the under surface of its leaves and flowers fragrant glands may be perceived. The order contains 2 or 3 genera, and nearly 100 species. *Example*—Ribes.

885. Order 94.—**Saxifragaceæ**, the Saxifrage Family. (*Polypet. Perigyn.*) Calyx superior, or more or less inferior (fig. 397 *c c*); sepals usually 5, more or less cohering at the base. Petals usually 5, perigynous, alternate with the lobes of the calyx (fig. 397 *p p*), rarely 0. Stamens perigynous (fig. 397 *e*), 5-10 or ∞, in 1 or more rows; anthers bilocular, with longitudinal or porous dehiscence. Disk often present, either annular or scaly. Ovary more or less completely united to the tube of the calyx, consisting usually of two carpels, cohering by their face (figs. 397, 398 *o*), but distinct and diverging at the apex; styles as many as the carpels, distinct (fig. 398 *t*) or combined; stigmas capitate (fig. 398 *s*) or clavate. Placentas (fig. 398 *p*) marginal (basal or apicilar), rarely central. Fruit generally a 1-2-celled capsule, the cells dehiscing at the ventral suture, and often divaricating when ripe. Seeds usually ∞, rarely definite; spermoderm often reticulated; embryo small, in the axis of fleshy albumen; radicle pointing to the hilum.—Shrubs or trees, or herbs, with alternate or opposite, usually exstipulate leaves. They are generally natives of temperate climates, and some of them characterize alpine districts. The order has been divided into the following suborders:—1. Escalloniеæ, petals and stamens 5; ovary inferior; style simple; albumen oily; evergreen shrubs, with alternate, simple, exstipulate leaves, found in the temperate regions of South America, often at a great elevation. 2. Cunonieæ, petals 4-5 or 0; stamens 8-10 or ∞; ovary half inferior; styles 2, distinct or combined; trees or shrubs, with opposite leaves, having interpetiolary stipules; found in South America, the East Indies, south of Africa, and Australasia. 3. Hydrangeæ, petals 4-6; stamens 8-12 or ∞; anthers sometimes biporose; ovary more or less inferior; styles 2-5, usually distinct; shrubs with opposite, sometimes whorled, exstipulate leaves, and flowers, frequently cymose, with the exterior flowers sterile and dilated; found chiefly in the temperate parts of Asia and America. 4. Saxifrageæ, petals 5 or 0; stamens 5-10; ovary more or less adherent; styles usually 2, and distinct; herbs, with alternate, usually exstipulate leaves, found in the mountainous regions of Europe, &c. Few of the plants are put to any use. Some of them are astringent, and used for tanning; others have bitter tonic properties. The glutinous exudation of a few of them is acrid. In the entire order there are 60 known genera, and upwards of 540

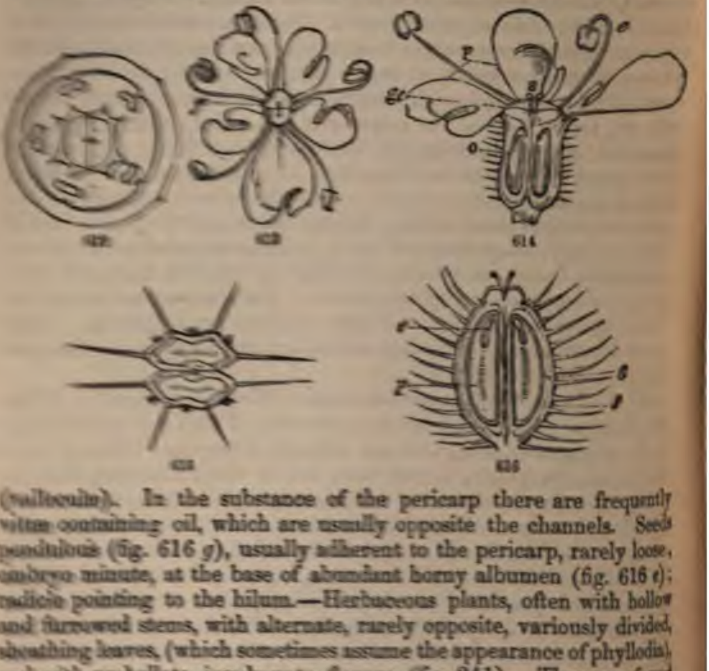
species. *Examples*—Escallonia, Itea, Cunonia, Weinmannia. Hydrangea, Bauera, Saxifraga, Chrysosplenium, Heuchera.

886. Order 95.—**Bruniaceæ**, the Brunia Family. (*Polypet. Epigyn.*) Calyx 5-cleft; æstivation imbricated. Petals inserted in the throat of the calyx, and alternate with its segments. Stamens alternate with the petals, arising from them, or from a disk surrounding the ovary; anthers introrse, 2-celled, with longitudinal dehiscence. Ovary usually adherent to the tube of the calyx, and 1-3-celled; ovules anatropal, suspended, 1 or 2 in each cell; style simple or bifid; stigmas 1-3. Fruit either bicoccous and 2-celled, or indehiscent and 1-celled, crowned by the persistent calyx. Seeds solitary or in pairs, suspended, sometimes with a short arillus; embryo minute, at the base of fleshy albumen; cotyledons short and fleshy; radicle conical, next the hilum. —Branched heath-like shrubs, with small, imbricated, rigid, and entire leaves, and small, often capitate flowers. They are natives principally of the Cape of Good Hope, and have no important properties. There are 15 known genera according to Lindley, and 65 species. *Examples* —Brunia, Staavia, Ophiria.

887. Order 96.—**Hamamelidaceæ**, the Witch-hazel Familly. (*Polypet. Epigyn.*) Calyx 4-5-lobed or truncate. Petals 4-5 or 0, inserted on the calyx, alternating with the calycine segments. Stamens twice as many as the petals, in two rows, one of which alternates with the petals and is fertile, the other is opposite to them and sterile; anthers bilocular, introrse. Ovary adherent, 2-celled; ovules solitary, or several (in Bucklandia and Sedgwickia), pendulous or suspended; styles 2. Fruit a 2-celled, 2-valved capsule, opening by loculicidal dehiscence. Seeds pendulous; embryo straight, in the axis of fleshy albumen; cotyledons leafy; radicle superior.—Shrubs or small trees, with alternate, petiolate, feather-veined, and stipulate leaves, and small axillary, bracteated, often unisexual flowers. They are found in various parts of Asia, Africa, and America. The seeds of *Hamamelis virginica* are used as food, while its leaves and bark are astringent and acrid. Authors notice 13 genera, including 19 species. *Examples*—Hamamelis, Fothergilla, Bucklandia, Rhodoleia.

888. Order 97.—**Umbelliferæ**, the Umbelliferous Family (figs. 612-616), Apiaceæ of Lindley. (*Polypet. Epigyn.*) Calyx superior, 5-toothed or entire. Petals 5, inserted on the outside of a fleshy epigynous disk, often with inflexed points (figs. 282, 613). Stamens 5, alternate with the petals, incurved in æstivation (figs. 613, 614). Ovary inferior, 2-celled, crowned with a double disk or stylopod (fig. 614 *g e*); ovules solitary, pendulous; styles 2, distinct (fig. 454 *s s*); stigmas simple. Fruit (figs. 615, 616) a cremocarp (¶ 543), consisting of two achænia (mericarps or hemicarps,) which adhere by their face (commissure) to a common axis (carpophore), from which they separate, and are suspended when ripe (fig. 454 *a*); each mericarp is

marked by five primary longitudinal ridges (juga), and often by four alternating secondary ones, the ridges being separated by channels (valleculæ). In the substance of the pericarp there are frequently vittæ containing oil, which are usually opposite the channels. Seeds pendulous (fig. 616 *g*), usually adherent to the pericarp, rarely loose, embryo minute, at the base of abundant horny albumen (fig. 616 *e*); radicle pointing to the hilum.—Herbaceous plants, often with hollow and furrowed stems, with alternate, rarely opposite, variously divided, sheathing leaves, (which sometimes assume the appearance of phyllodia), and with umbellate, involucrate flowers (fig. 241). They are found chiefly in the northern parts of the northern hemisphere. In warm countries they occur at high elevations. The order has been divided according to the number and size of the pericarpial ridges, the presence or absence of vittæ, and the form of the albumen. The following are the several sections, which, however, are not considered altogether satisfactory:—1. Orthospermæ (ὀρθός, straight, and σπέρμα, seed), albumen flat on the inner face, neither involute nor convolute.



Figs. 612-616.—Organs of fructification of Daucus Carota, common Carrot, to illustrate the order Umbelliferæ.

[redacted] Diagram of the flower, with a 5-toothed calyx, 5 inflexed petals, 5 stamens, and ... by 2 carpels, with primary and secondary ridges, valleculæ, commissure, and flat ...

The flower viewed from above, showing the petals with inflexed points and ... Epigynous disk or stylopod.

Vertical section of the flower. p, Petals with inflexed points. s, Stamens ... the apex. o, Ovary formed by two carpels, adherent to the calyx throughout ... stigmas. ep, Epigynous disk or stylopod.

Horizontal section of the fruit (cremocarp) with bristly ridges.

Vertical section of the cremocarp. f, Pericarp. g, Seed. p, Flat perisperm.

2. Campylospermæ (καμπύλος, inflected), albumen curved at the margins, so as to form a longitudinal furrow. 3. Cœlospermæ (κοῖλος, concave), albumen curved at the ends (from base to apex). Authors enumerate 291 genera, including 1576 species. *Examples*—Hydrocotyle, Eryngium, Apium, Bupleurum, Æthusa, Angelica, Heracleum, Daucus, Myrrhis, Conium, Coriandrum.

889. The properties of the plants of this order are various. Some yield articles of diet, others gum-resinous and oily substances, while others are highly poisonous. According to their qualities, the species have been divided into—1. Those which are harmless, and are used as esculent vegetables. 2. Those producing a gum-resin, often having a fetid odour from the presence of a sulphur-oil, and which are used as antispasmodics and stimulants. 3. Those yielding a volatile oil, which renders them carminative and aromatic. 4. Those which are poisonous, in consequence of the presence of an acrid and narcotic juice.

890. Among esculent species may be noticed—*Daucus Carota* (Carrot), *Pastinaca sativa* (Parsnip), *Apium graveolens* (Celery), *Fœniculum vulgare* (Fennel), *Petroselinum sativum* (Parsley), *Anthriscus Cerefolium* (Chervil), *Sium Sisarum* (Skirret), and *Archangelica officinalis* (Angelica). *Crithmum maritimum* is the Samphire, which grows abundantly on rocks near the sea, and is used as a pickle. The roots of *Arracacha esculenta*, a native of Grenada, have been recommended as a substitute for the potato; they are large and esculent, resembling a Parsnip in quality. The root of *Eryngium campestre* and *maritimum*, or Eryngo, is sweet, aromatic, and tonic. Boerhaave reckons it as the first of aperient diuretic roots. The tubers of *Bunium Bulbocastanum* and *flexuosum* are eaten under the name of Pig-nuts or Earth-nuts. *Prangos pabularia*, a plant of Southern Tartary, is highly recommended as fodder for cattle.

891. Many species yield milky juices, which concrete into a fetid gum-resin. Assafœtida is procured from the *Ferula Assafœtida* of Linnæus, which has recently been described by Dr. Falconer under the name of *Narthex Assafœtida*. The plant is found in Persia and Affghanistan, and seeds of it have been sent to this country by Dr. Falconer, some of which have germinated in the Edinburgh Botanic Garden, and produced abundance of flowers and fruit. The fruit of the plant is distinguished by divided and interrupted vittæ, which form a network on the surface, and its leaves have a resemblance to those of a Pæony. It would appear that *Ferula persica*, a plant with very much divided leaves, yields an inferior sort of assafœtida. The assafœtida is procured by taking successive slices off the top of the root, and collecting the milky juice which is allowed to concrete in masses It consists of resinous and gummy matter, with a sulphur-oil similar to that of Garlic, which is probably its active ingredient. It is employed medicinally in substance or tincture, as a

stimulant, antispasmodic, and anthelmintic. Ammoniac, another fetid gum-resin, is the produce of *Dorema Ammoniacum* (probably *Diserneston gummiferum* of Jaubert and Spach), a native of Persia. It contains resin, gum, and volatile oil, and is used medicinally as a stimulant, antispasmodic, and expectorant. Galbanum, which seems to be the חֶלְבְּנָה of Scripture, is procured, in all probability, from *Opoidia galbanifera* of Lindley. There are doubts, however, as to its botanical source. Don referred it to *Galbanum officinale*. It consists of resin, gum, and volatile oil, and is used as an antispasmodic and emmenagogue. Opoponax is another gum-resin, procured from *Opoponax Chironum* (*Pastinaca Opoponax*), a native of the southern parts of Europe. Sagapenum seems to be the produce of a species of *Ferula*.

892. There are other species which supply a carminative and aromatic oil. From the fruits of *Carum Carui*, which are commonly called Caraway seeds, a volatile oil of this nature is procured. Oils of a similar kind are obtained from the fruit of *Pimpinella Anisum* (Anise), from that of *Fœniculum vulgare*, or *F. dulce* (common Fennel), *Anethum graveolens* (common Dill), *Coriandrum sativum* (Coriander), the גַּד of the Bible, *Cuminum Cyminum* (Cumin), *Archangelica officinalis* (Garden Angelica), and *Daucus Carota* (Carrot).

893. In regard to the poisonous species of this order, there is still much to be learned. They appear to vary according to the soil and climate in which they grow. Some species, generally reputed poisonous, have been found by Dr. Christison to be quite innocuous when gathered from localities in the neighbourhood of Edinburgh. The most important plant of this section is *Conium maculatum* (Hemlock), the *κώνειον* of the Greeks. It is a biennial plant, found abundantly in Britain, and distinguished by its undulated ridges, smooth purple-spotted stem, and the peculiar mouse-like odour of its leaves, when being dried. Every part of the plant, especially the fresh leaves and green fruit, contain a volatile oleaginous alkali, called Conia, which acts as an energetic poison. To this substance the effects of hemlock on the animal frame are due, and care is required in the preparation of the leaves and fruit in order to retain this active principle. A few drops of Conia will kill a small animal. It acts on the spinal cord, producing paralysis with slight convulsive twitches, and its fatal effects are attributed to asphyxia, produced by palsy of the muscles of respiration, without convulsions or coma. Hemlock has been employed medicinally to allay pain, more especially in cancerous and neuralgic affections. *Œnanthe crocata* (Hemlock-Dropwort, or Dead-tongue), and a variety called *apiifolia*, have been long looked upon as poisonous. The roots have been mistaken for parsnips, and fatal effects have been thus produced. It would appear, however, that these poisonous qualities are not invariably present, for Dr. Christison found that the

roots of this plant, when growing in a sea-side locality, near Edinburgh, were innocuous. It remains to be determined if the climate and locality have any effect in modifying the properties of the plant. The same remarks may be made in regard to *Œnanthe Phellandrium* (Water Dropwort), and *Cicuta virosa* (Water Hemlock or Cowbane), which seem to vary as regards their poisonous properties. *Æthusa Cynapium* (Fool's Parsley), is another plant of the order reputed poisonous. It has been stated that the roots of Parsnip, during the spring of the second year, on the approach of the flowering season, occasionally produce a poisonous matter.

894. Order 98.—**Araliaceæ**, the Ivy Family. (*Polypet. Epigyn.*) Calyx entire or toothed (fig. 309 *c*). Petals definite (fig. 309 *p*), 2, 5, 10, deciduous, occasionally 0; æstivation valvate. Stamens as many as the petals, or twice as many, inserted below the margin of an epigynous disk (fig. 309 *e e*). Ovary adherent to the tube of the calyx, 2 or more celled (fig 309 *o*); ovules solitary, pendulous (fig. 309), anatropal; styles 2 or more, distinct or connate (fig. 309 *s*); stigmas simple. Fruit usually succulent, 2-15-celled, covered by the calycine limb. Seeds solitary, pendulous, adhering to the endocarp; albumen fleshy; embryo small; radicle pointing to the hilum.—Trees, shrubs, or herbaceous plants, with alternate exstipulate leaves, and umbellate (fig. 240) or capitate flowers. They are found both in tropical and in cold regions. Authors enumerate 24 genera, including 180 species. *Examples*—Aralia, Panax, Adoxa, Hedera, Helvingia.

895. They have generally aromatic and stimulant properties. They are allied to Umbelliferæ, but do not possess poisonous qualities in a marked degree, nor does their fruit usually yield volatile oil. A species of *Panax* yields the famous Ginseng root of the Chinese, which is used as a stimulant. The celebrated Rice Paper of the Chinese is ascertained to be prepared from the pith of a plant of this order, called by Sir William Hooker, *Aralia papyrifera*. *Panax quinquefolium* possesses qualities resembling those of ginseng. Some species of *Aralia* yield an aromatic gum-resin. *Aralia nudicaulis*, a native of North America, has fragrant and aromatic roots, which are used as a substitute for sarsaparilla. *A. spinosa*, called toothache-tree in North America, is a stimulant diaphoretic. The succulent fruit of *Hedera Helix*, the Ivy, is emetic and purgative.

896. Order 99.—**Cornaceæ**, the Cornel Family. (*Polypet. Epigyn.*) Calyx 4-lobed. Petals 4, oblong, broad at the base, regular, inserted into the upper part of the calycine tube; æstivation valvate. Stamens 4, inserted along with the petals, and alternate with them; anthers dithecal. Ovary adherent to the tube of the calyx, 2-celled, crowned by a disk; ovules solitary, pendulous, anatropal; style filiform; stigma simple. Fruit fleshy, crowned by the limb of the calyx, 2-celled, rarely 1-celled by abortion; endocarp bony (fig. 473). Seeds solitary,

pendulous; embryo straight, long, in the axis of fleshy albumen; radicle superior, shorter than the oblong cotyledons.—Trees, shrubs, or herbs, with opposite, very rarely alternate, exstipulate leaves, and capitate, umbellate, or corymbose flowers. They inhabit the temperate climates of Europe, Asia, and America. The bark of *Cornus florida* and *sericea* is used in America as a tonic and febrifuge. The fruit of *Cornus mascula* has been used as food, and the seeds of *Cornus sanguinea* furnish oil. From the wood of *Cornus mascula*, or *Akenia* of the Greeks, the Kizziljiek or Redwood of Turkey, the Turks obtain the dye for their red fez. The fruit stewed and mixed with water forms a good drink in hot weather, and from its astringency it is useful in diarrhœa. The fruit of *Cornus suecica*, a species found on the Scotch mountains, is reputed tonic. *Aucuba japonica* has leaves which exhibit a variegated aspect. Authors give 10 genera, and 42 species. *Examples*—Cornus, Aucuba.

Section 2.—GAMOPETALÆ.

897. Petals united; stamens usually epigynous. This subclass includes the Monopetalous orders of Jussieu, and the Gamopetalæ of Endlicher, in which the ovary is inferior, or in other words, in which the calyx is adherent.

898. Order 100.—**Loranthaceæ**, the Mistleto Family. (*Monopet. Epigyn.*) Calyx arising from a tube, or rim, which some regard as an expansion of the pedicel, often bracteated. Petals (or according to others, sepals) 4-8, distinct, or more or less united; æstivation valvate. Stamens equal in number to the petals, and opposite to them; filaments more or less united to the petals; anthers 1- 2- or many-celled (¶ 405). Ovary unilocular, adherent to the calycine tube or the expanded pedicel; ovules with a naked nucleus, erect or suspended; style filiform or 0; stigma simple. Fruit succulent, crowned by the calyx, 1-celled. Seed solitary, pendulous; embryo straight, in the axis of fleshy albumen; cotyledons either minute or numerous; radicle superior.—Shrubs, usually parasitical, with opposite or alternate, fleshy exstipulate leaves. Many of the plants have showy flowers, which hang from the trunks and branches of trees in the equinoctial parts of Asia and America. Some occur in temperate regions. Lindley gives 30 genera, and 430 species. *Examples*—Loranthus, Viscum, Myzodendron.

899. Disputes have taken place as to the structure of the flowers in this order, some considering the petals as being in reality sepals, and regarding the calycine rim as being an expansion of the pedicel only. The wood of some of the plants is arranged in separate wedges, and r vessels are either annular or scalariform. The fruit contains a d matter, like bird-lime, by means of which the seeds adhere to

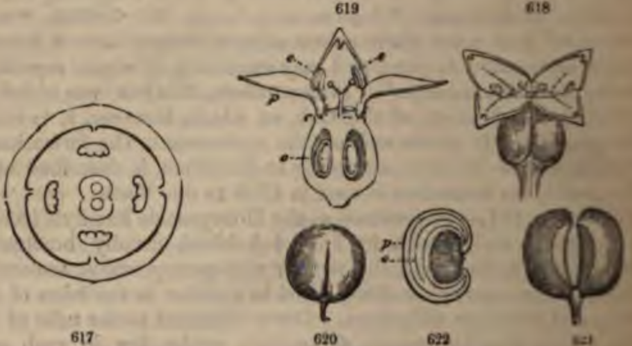
trees. The seeds in germinating send their radicles into the plant to which they are attached, and grow afterwards as true parasites, selecting certain chemical ingredients in preference to others. The bark is usually astringent. Griffith has carefully described the nature of the parasitism of those plants. He states that in Loranthus, the ripe seeds adhere firmly to the substance on which they are applied by means of their viscid coating, which hardens into a transparent glue. In two or three days after application, the radicle curves towards its support, and as soon as it reaches it becomes enlarged and flattened. By degrees a union is established between the woody system of the parasite and stock, after which the former lies exclusively on the latter, the fibres of the sucker-like root of the parasite expanding on the wood of the support. Before this occurs the parasite is nourished by its own albumen, which is gradually absorbed. "As soon as the young parasite has acquired the height of one or two inches, when an additional supply of nourishment is perhaps required, a lateral shoot is sent out, which is, especially towards the point, of a green colour. This at one, or two, and subsequently at various points, adheres to the support by means of sucker-like productions, which are precisely similar in structure and mode of attachment to the original seminal one." The fibres of the parasite never penetrate beyond their original attachment; in the adult the sucker-bearing shoots frequently run to a considerable distance. "I have seen," says Mr Griffith, "such shoots which had taken their course *along a decayed branch* become replaced, and *return in quest*, as I may express it, *of a part capable of affording some nourishment.*" *Viscum album*, Mistleto, was called by the Druids the Mistleto of the Oak, on which, however, it is rarely found parasitic. It grows well on the apple-tree. The formation of the ovule in the Mistleto, according to Schleiden, is described at ¶ 463. *Loranthus tetrandrus* is used in Chili to dye black.

900. Order 101.—**Caprifoliaceæ**, the Honeysuckle Family. (*Monopet. Epigyn.*) Calyx with its limb 4-5 lobed, usually bracteated. Corolla superior, lobed, usually regular and gamopetalous, sometimes irregular. Stamens epicorolline, equal in number to the lobes of the corolla, and alternate with them. Ovary adherent to the tube of the calyx, usually 3-celled, rarely 4-5-celled; ovules few in each cell, pendulous; style one or none; stigmas 3-5. Fruit fleshy or dry, crowned by the limb of the calyx, indehiscent, uni- or multilocular; endocarp sometimes bony. Seeds solitary, or several in each cell, pendulous; spermoderm often bony; embryo small in the centre of fleshy albumen; radicle next the hilum.—Shrubs or herbs, with opposite exstipulate leaves, and corymbose flowers. Chiefly found in the northern parts of Europe, Asia, and America; found very sparingly in northern Africa, and little known in the southern hemisphere. The order has been divided into two suborders:—1. Lonicereæ, the

true Honeysuckles, with a regular rotate or tubular corolla, three sessile stigmas, and a raphe on the inner side of the ovule. 2. Sambuceæ, the Elder Tribe, with a corolla more or less tubular, often irregular, a filiform style, and a raphe on the outside of the ovule. Lindley gives 16 genera, and 221 species. *Examples*—Lonicera, Caprifolium, Leycesteria, Linnæa, Sambucus, Viburnum.

901. Many of the plants, such as the Honeysuckle and Elder, have odoriferous flowers. Some possess emetic and purgative properties. The fruit of *Sambucus nigra*, the Common Elder, is used in the manufacture of a kind of wine. The flowers contain a small quantity of concrete volatile oil, and a minute portion of a volatile odoriferous oil. The inspissated juice of the fruit, and the inner bark, possess purgative qualities. *Viburnum Opulus*, the Gueldres Rose, is often cultivated in gardens. *Viburnum Lantana* has an acrid bark. *Linnæa borealis* is a delicate northern plant, named after Linnæus. *Symphoricarpus racemosa* yields the Snowberry.

902. Order 102.—**Rubiaceæ**, the Madder and Peruvian Bark Family. (*Monopet. Epigyn.*) Calyx adherent with the ovary, the limb with a definite number (usually 4-5) of divisions, sometimes obsolete (fig. 619 *c*). Corolla gamopetalous, regular, tubular, or rotate (fig. 619 *p*), inserted into the calyx, usually with 4-5 divisions (fig. 618); æstivation valvate or imbricate. Stamens more or less adherent to the corolline tube, as many as the lobes of the corolla, and alternate



Figs. 617-622.—Illustrations of the natural order Rubiaceæ.

Fig. 617.—Diagram of the flower of Galium Mollugo, belonging to the section Stellatæ. Ca nearly obsolete, corolla rotate, 4-lobed, 4 stamens, and didymous ovary.

Fig. 618.—Flower entire.

Fig. 619.—Flower cut vertically. *c*, Calyx adherent to the ovary, *o*, which is 2-celled. *p*, Corolla. *e e*, Stamens surrounding the style and stigmas.

Fig. 620.—Fruit of Rubia tinctoria, Madder.

Fig. 621.—The same, showing the separation of the two carpels.

Fig. 622.—The seed cut vertically. *p*, Perisperm. *e*, Curved embryo.

with them (fig. 617). Ovary inferior, usually bilocular (fig. 619 *o*), sometimes multilocular, crowned with a fleshy disk; ovules numerous or solitary, anatropal or amphitropal; style single, sometimes partly divided; stigmas usually 2, more or less distinct (fig. 619). Fruit inferior, 2- or many-celled, dry or succulent, either indehiscent or splitting into two mericarps (figs. 620, 621). Seeds 1 or many in each cell, in the former case erect or ascending (fig. 619), in the latter attached to a central placenta; albumen copious, horny or fleshy (fig. 622 *p*); embryo small, straight, or slightly curved (fig. 622 *e*); cotyledons leafy; radicle turned to the hilum.—Trees, shrubs, or herbs, with simple, entire, opposite, or verticillate leaves, which have either interpetiolary stipules (fig. 190), or are exstipulate. The order has been divided into two suborders:—1. Cinchoneæ, with rounded stems, usually opposite leaves, and interpetiolary stipules (fig. 190), natives of the hotter parts of the world. 2. Galieæ, or Stellatæ, with square stems, verticillate leaves, and no stipules; natives of northern and colder regions. Lindley considers these divisions as separate natural orders. Some authors think that the verticillate leaves of Stellatæ consist partly of true leaves, and partly of stipules. The order includes nearly 350 genera, and upwards of 3000 known species. *Examples*—Cinchona, Gardenia, Hedyotis, Isertia, Hamelia, Guettarda, Pæderia, Coffea, Cephælis, Psychotria, Spermacoce, Anthospermum, Opercularia, Galium, Rubia.

903. The properties of the order, in general, are tonic, febrifuge, and astringent. Many important articles of materia medica are furnished by the plants in the suborder Cinchoneæ. Peruvian or Jesuits' Bark, Quinquina of the French, China of the Germans, known under the vague and ill-defined names of Pale, Yellow, and Red Bark, is procured from various species of *Cinchona*, which grow abundantly in the district of Upper Peru. The Cinchona trees seem to be confined exclusively to the Andes, within the boundaries of Peru, Columbia and Bolivia, from 11° north lat. to 20° south lat., chiefly growing at elevations varying from 3000 to 9000 feet above the level of the sea, and in a dry rocky soil. The barks are met with either in thick, large, flat pieces, or in thinner pieces, which curl inwards during drying, and are called quilled. Britain is said to import from 225,000 to 556,000 lbs. annually, and to retain 120,000 lbs. for home consumption. At least twelve species are supposed to furnish commercial barks, but great obscurity prevails as to the species to which the various kinds of bark should be referred. The chief officinal kinds are: 1. Crown-bark, China-loxa, a pale bark in quills 6 to 15 inches long, the produce of *Cinchona condaminea*, which inhabits the mountains in the vicinity of Loxa, at an elevation of from 5700 to 7500 feet. 2. Gray bark, Silver bark, or Huanuco bark, China-Huanuco, another variety of quilled pale bark, obtained from *Cinchona nitida* and *mi-*

crantha, found near Huanuco, Peru. 3. Yellow bark, China-regia, or Calisaya bark, partly flat, partly quilled, procured from *Cinchona Calisaya*, which grows around Apolobamba. 4. Red bark, China-rubra, partly flat and partly quilled, procured from an unknown species. Besides these, there are various inferior kinds of bark met with in commerce, such as Ash bark, China-Jaen, from *Cinchona ovata;* hard Carthagena bark, China-flava-dura, from *Cinchona cordifolia;* Rusty bark, China-Huamalies, from *C. condaminea*, var. *Chatmarguera;* Orange-bark, from *C. lancifolia;* and Red bark of Santa-Fé, from *Cinchona magnifolia.* The following is the arrangement adopted by Pereira:—

A. True Cinchonas with a Brown Epidermis.

I. Pale Barks.

1. Crown or Loxa Bark	Cinchona condaminea, *H.* and *B.*
2. Gray, or Silver, or Huanuco Bark...	Cinchona micrantha, *R.* and *P.* (*C.* scrobiculata, *H.* and *B.*)
3. Ash or Jaen Bark........................	Cinchona ovata, *Fl. Peruv.*
4. Rusty or Huamalies Bark..............	C. condaminea, *var.* chatmarguera, De Cand.

II. Yellow Barks.

5. Royal, Yellow, or Calisaya Bark ...	Cinchona Calisaya, Wedd.

III. Red Barks.

6. Red Bark	Cinchona sp.?

B. True Cinchonas with a White Epidermis.

I. Pale Barks.

7. White Loxa Bark............	Cinchona sp.?

II. Yellow Barks.

8. Hard Carthagena Bark	Cinchona cordifolia, *Mutis.*
9 Fibrous Carthagena Bark	C. condaminea, *var.* lancifolia.
10. Cuzco Bark..................................	C. pubescens, *Vahl.* (C. purpurea, *R.* and *P.*)
11. Orange Bark of Santa Fé...............	C. lancifolia, *Mutis* (C. angustifolia, *P.*)

III. Red Barks.

12. Red Bark of Santa-Fé..................	C. oblongifolia, *Mutis* (C. magnifolia *R.* and *P.*)

Cinchona bark contains three alkalis, Cinchonine, Quinine, and Quini-
to which its active properties are due; the first is best obtained
Cusco bark, the second from Yellow bark, and the third
ibrous Carthagena bark. They exist in combination with
acid. Cinchona bark is used medicinally as a tonic and anti-
c, in cases of dyspepsia, neuralgia, and intermittent fever
been administered in the form of infusion and tincture

but at present, the disulphate of Quina is the chief preparation used. The genus *Exostemma* yields various kinds of false Cinchona bark, which do not contain the Cinchona alkalis. In this genus the stamens are exserted, whereas in Cinchona they are included. The following are some of the false barks noticed by Pereira :—

1. St. Lucie or Piton Bark	Exostemma floribundum.
2. Jamaica Bark	E. caribæum.
3. Pitaya Bark	Exostemma sp. ?
4. False Peruvian Bark	E. peruvianum.
5. Brazilian Bark	E. souzianum.

Pinckneya pubens yields the fever-bark of Carolina.

904. Some of the plants of this order have emetic and purgative qualities. *Cephāelis Ipecacuanha* yields the Ipecacuanha of the Pharmacopœia. The plant is found in the woods of several Brazilian provinces, as Pernambuco, Bahia, and Rio Janeiro. The roots which are the officinal part, are contorted, knotty, and annulated, and about the thickness of a goose-quill. They are used as emetic and diaphoretic remedies, in the form of powder or wine. Their active ingredient is an alkaloid called Emeta or Emetine. Besides this brown or gray annulated Ipecacuanha, there are spurious kinds, such as striated or Black Peruvian Ipecacuanha, the produce of *Psychotria emetica*, and white or amylaceous Ipecacuanha, furnished by *Richardsonia scabra* (*brasiliensis*,) a native of the provinces of Rio Janeiro and Minas Geräes. Some of the species of *Psychotria*, *Cephāelis*, and *Randia*, are said to act so violently as to produce poisonous effects.

905. Among the astringent plants of the order may be noticed *Uncaria Gambir*, which supplies a kind of Catechu, known by the name of Gambeer. Of the plants furnishing articles of diet, the most important is *Coffea arabica*, a native of Arabia and of the borders of Abyssinia, which furnishes the Coffee of commerce. The fruit is succulent, and the horny albumen of the seed is the part used as a beverage. It contains a bitter principle, denominated Caffein, which is identical with that got from Tea. The import of Coffee into the United Kingdom, in 1847, was 19,783 tons, and in 1848, it was 24,553 tons. The seeds of some other plants of the order, as species of *Galium*, have been used as substitutes for Coffee. Among the plants yielding dye, the most interesting is *Rubia tinctoria*, the root of which is the Madder of commerce. It contains three volatile colouring matters—madder purple, orange, and red. The latter is in the form of crystals, having a fine orange-red colour, and called Alizarine. This is the substance which yields the turkey-red dye. *Rubia Munjista*, (*cordifolia*), Munjeet, is also used for a similar purpose. *Oldenlandia umbellata* is employed in the East Indies as a substitute for Madder, and so is the root of *Morinda citrifolia*, under the name of Sooranjee. The latter yields a peculiar colouring matter, called by Dr. Anderson, Morindine. It

is extracted from the bark of the root, and is procured in the form of minute acicular crystals of a fine yellow colour. It is incapable of producing colours with alum and iron mordants, but with turkey-red mordant it produces a dark red. Many of the plants of this order, especially in the section Cinchoneæ, have very showy and fragrant flowers. The species of *Mussænda* and *Calcophyllum*, are remarkable on account of one of their sepals becoming large and showy. *Asperula odorata*, Wood-ruff, gives out its fragrance when dried.

906. Order 103.—**Valerianaceæ**, the Valerian Family. (*Monopet. Epigyn.*) Calyx superior, its limb being either membranous or pappose. Corolla gamopetalous, inserted into the top of the ovary, tubular, 3-4-5-lobed, sometimes gibbous or spurred at the base. Stamens 1-5, adherent to the corolla and alternate with its lobes. Ovary inferior, 1-3-celled; ovule solitary, pendulous, style filiform; stigmas 1-3. Fruit dry, indehiscent, crowned by the limb of the calyx, 1-celled, in consequence of 2 cells being abortive. Seed solitary, pendulous, exalbuminous; embryo straight; radicle superior.—Herbs, with opposite exstipulate leaves, and cymose inflorescence. They are found in temperate climates. Authors give 13 genera, and 193 species. *Examples*—Patrinia, Valeriana, Centranthus.

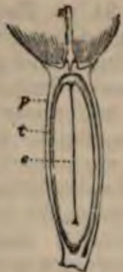
907. The plants belonging to the order are strong scented or aromatic, and some of them have been used as bitter tonics, anthelmintics, and antispasmodics. The root of *Valeriana officinalis* is the common medicinal Valerian. It has a bitter acrid taste, and a peculiar odour, which is fetid and disagreeable in the dry state. In the form of tincture and infusion, it is prescribed in cases of hysteria. Other species of Valerian, as *V. celtica*, *Phu*, *sitchensis*, and *Saliunca*, have similar properties. Valerian is known to have a peculiar effect on cats, causing a species of intoxication. *Nardostachys Jatamansi* is the נֵרְדְּ, νάρδος, or spikenard of the ancients, which was highly prized on account of its perfume. *Valerianella olitoria*, Lamb's lettuce, is used as a salad. Many of the plants in the order secrete a peculiar volatile oil, to which these properties are due.

908. Order 104.—**Dipsacaceæ**, the Teazel Family. (*Monopet. Epigyn.*) Calyx superior, with an entire, or toothed, or pappose limb (fig. 278). Corolla gamopetalous, tubular, inserted on the calycine tube, with an oblique 4-5-lobed limb; æstivation imbricated. Stamens 4, attached to the tube of the corolla, and alternate with its lobes; anthers dithecal, distinct. Ovary cohering with the tube of the calyx, either closely or only at the apex, unilocular; ovule solitary, pendulous, anatropal; style filiform; stigma simple. Fruit dry, indehiscent, crowned by the limb of the calyx, covered by an epicalyx or involucellum, 1-celled. Seed solitary, pendulous, albuminous; embryo straight; radicle superior.—Herbs or undershrubs, with opposite or verticillate leaves, and capitate or verticillate flowers.

surrounded by a many-leaved involucre (figs. 232, 244). They are found in the south of Europe, the Levant, and at the Cape of Good Hope. The properties of the order are unimportant. The name *Dipsacus* is derived from δίψα, thirst, in consequence of the bases of the leaves of some of the species being connate, in such a way as to enclose a cavity which contains water ready to allay thirst. Common Teazel is hence called Venus's Bath; the water contained in which was considered good for bleared eyes. The heads of *Dipsacus fullonum*, Fullers' Teazel, on account of their spiny bracts, are used in dressing cloth. Some of the species are reputed febrifugal. *Scabiosa succisa* is said to yield a green dye, and has from its astringent qualities attracted the attention of tanners. Lindley mentions 6 genera, including 156 species. *Examples*—Morina, Scabiosa, Dipsacus.

909. Order 105.—**Calyceraceæ**, the Calycera Family. (*Monopet. Epigyn.*) Calyx superior, with a limb of 5 unequal segments. Corolla regular, infundibuliform, with a long slender tube, and a 5-lobed limb, the lobes having each three principal veins. Stamens 5, attached to the tube of the corolla, with as many alternating glands below them; filaments monadelphous; anthers partially united. Ovary inferior, 1-celled; ovule solitary, pendulous; style single, smooth; stigma capitate. Fruit an achænium, crowned by the rigid spiny segments of the calyx, sometimes covered with papillæ, which emit spiral tubes when placed in water. Seed solitary, pendulous; embryo in the axis of fleshy albumen; radicle superior.—Herbaceous plants, with alternate, exstipulate leaves, and sessile capitate flowers, surrounded by an involucre. They inhabit South America, rarely occurring in the tropical districts, but more plentiful in South Chili. Their properties are unknown. There are 9 known genera according to Authors, and 10 species. *Examples*—Calycera, Boopis.

910. Order 106.—**Compositæ** (Asteraceæ of Lindley, and Synantheræ of other authors), the Composite Family. (*Monopet. Epigyn.*) (Figs. 623–634). Calyx superior, its limb either wanting or membranous, or divided into bristles, paleæ, or hairs, and called pappus (figs. 277, 279, 626 *a*). Corolla gamopetalous, ligulate (figs. 301, 624) or tubular (fig. 626 *p*), in the latter case usually 5-toothed, sometimes bilabiate (fig. 625); two marginal veins, containing spiral cells, run along each of the corolline divisions, and afterwards proceed along the axis of these divisions; æstivation valvate. Stamens usually 5, alternate with the teeth of the corolla (fig. 626 *e*); filaments distinct; anthers (figs. 301 *a*, 624, 625, 626 *e*) cohering into a cylinder (synantherous or syngenesious). Ovary inferior, closely adherent to the tube of the calyx (figs. 624, 625, 626 *o*, 634), and undistinguishable from it, 1-celled; ovule solitary, erect (figs. 423, 626, 634); style simple, sometimes with collecting hairs (fig. 627); stigmas two, distinct (figs. 404, 627-633) or united. Fruit, an achænium



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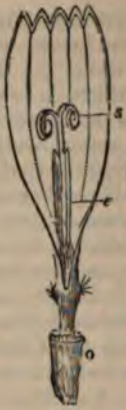

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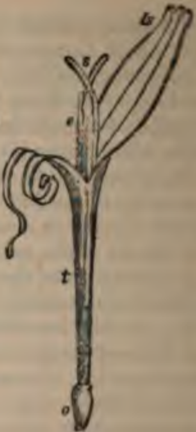

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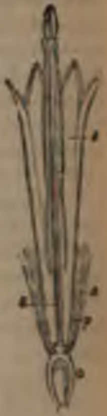

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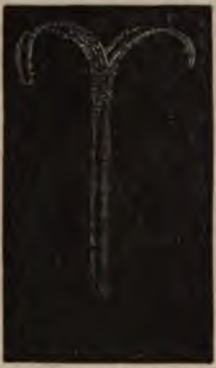

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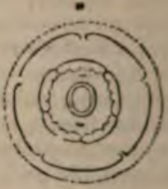

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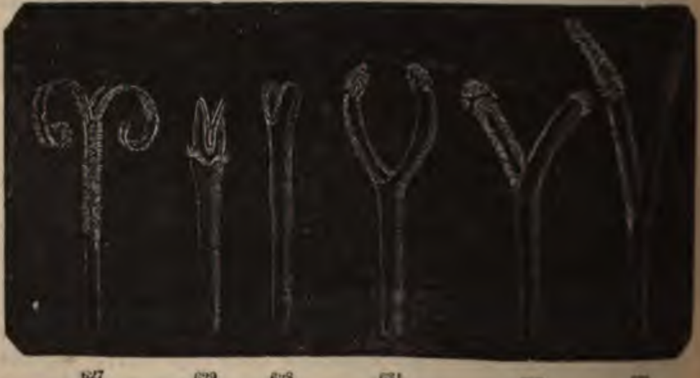


627 629 628 631 630 632

Cypsela, ¶ 542), crowned with the limb of the calyx (fig. 634). Seed olitary, erect, exalbuminous (fig. 634); radicle inferior.—Herbs or hrubs, with alternate or opposite, exstipulate leaves, and capitula of lowers (called florets), which are either hermaphrodite or unisexual, nd are surrounded by bracts in the form of an involucre (figs. 242, 43). Bractlets are sometimes interspersed with the flowers on the eceptacle, and are then called paleæ. Some of the flowers belong to he cyanic, others to the xanthic series (¶ 679). In the same head he flowers are sometimes homochromous (ὅμος, similar, and χρῶμα, olour), belonging to the same series; at other times they are heterohromous (ἕτερος, diverse), belonging to different series,—the ligulate o the cyanic, and the tubular to the xanthic.

911. This is one of the largest, and, at the same time, one of the nost important natural families in the vegetable kingdom. The plants vere all included by Linnæus in his class Syngenesia, and were diided into five orders according to the sexes of the florets, and the ature of the involucre. These divisions are given at page 356, under he names Polygamia Æqualis, Superflua, Frustranea, Necessaria, and egregata. The following series of terms have also been employed to xpress the nature of the capitula, as regards stamens and pistils:—

1. Homogamous (ὁμὸς, alike, and γάμος, marriage), flowers all hermaphrodite (☿).
2. Heterogamous (ἕτερος, diverse), the flowers of the disk (centre) hermaphrodite, those of the ray (circumference) either pistillate (female) only, or neutral, *i e.* destitute both of stamens and pistils.
3. Monœcious, ♂ — ♀, male and female flowers in the same capitulum.

Figs. 623-634.—Organs of fructification of Compositæ.

Fig. 623.—Diagram of the flower of a Senecio. The outer dotted circle indicates the pappose mb of the calyx, within it is the tubular corolla with five divisions, next five stamens with nited anthers, and in the centre the 1-celled, 1-seeded ovary.

Fig. 624.—One of the ligulate flowers or florets of Cichorium Intybus, Succory or Chicory, elonging to the section Cichoraceæ. *o*, Ovary completely adherent to the tube of the calyx. the mb of the calyx forming a crown surrounding the base of the ligulate (strap-shaped) corolla, hich has five apicilar divisions. *e*, Cylinder formed by the anthers (synantherous), traversed y the style with its bifid stigma, *s*.

Fig. 625.—Flower of Chætanthera linearis, belonging to the section Labiatifloræ. *o*, Ovary ith adherent calycine tube. *t*, Tube of the gamopetalous bilabiate corolla. *l s*, Upper lip of the rolla. *l i*, Lower lip of the corolla. *e*, Tube of the anthers. *s*, The bifid stigma at the apex of e style.

Fig. 626.—Tubular (flosculous) flower of Aster rubricaulis, belonging to the section Corymiferæ, cut longitudinally, to show the erect ovule, *o*, enclosed in the pericarp, consisting of the alls of the ovary, and the calycine tube incorporated. *p*, United petals. *a*, Pappus, consisting f the altered limb of the calyx. *e*, Stamens with their united anthers, attached to the corolla. Style traversing the antherine tube.

Figs. 627-633.—Summits of the styles of plants belonging to different tribes of Compositæ. Two gmatic bands are seen bordering the internal surface of the two branches, which terminate ch of these styles. Several have collecting hairs at different parts.

Fig. 627.—Summit of the style of Cichorium Intybus, one of the Cichoraceæ.
——— Chætanthera linearis, one of the Labiatifloræ.
——— Thevenotia, one of the Cynareæ.
——— Senecio Doria, one of the Senecionideæ.
——— Aster adulterinus, one of the Asteroideæ.
——— Stevia purpurea, one of the Eupatoriaceæ.
——— Vernonia angustifolia, one of the Vernoniaceæ.

34.—Ripe fruit (Cypsela) of a Senecio, cut vertically. *e*, Exalbuminous embryo, with ferior radicle. *t*, Spermoderm or covering of the erect seed. *p*, Pericarp consisting of ovarian arietes with the closely-adherent calycine tube. *s*, Style.

4. Heterocephalous (ἕτερος, diverse, and κεφαλή, a head), some capitula entirely male, others entirely female, in the same plant.
5. Diœcious, ♂ : ♀, some plants with male capitula only, others with female capitula only.

The following series of terms have been used to express the nature of the capitula, as regards the form and arrangement of the flowers:—

1. Discoid or Flosculous, corollas all tubular.
2. Ligulate or Semiflosculous, corollas all ligulate.
3. Radiate, corollas of the margin or ray ligulate, those of the centre or disk tubular.
4. Falsely-discoid, corollas all bilabiate.
5. Falsely-radiate, or radiatiform, corollas of the margin ligulate, those of the centre bilabiate.

912. Jussieu divided the order into three sections:—1. Cynarocephalæ (*cynara*, the artichoke), having the flowers all flosculous (tubular); involucre hard, conical, and often spiny. 2. Corymbiferæ (*corymbus*, a corymb, and *fero*, I bear), having flosculous (tubular) florets in the disk (centre), and ligulate (semiflosculous) in the ray (circumference); involucre hemispherical, leafy, or scaly, seldom spiny. 3. Cichoraceæ (*cichorium*, succory), having the florets all ligulate. Another section was subsequently added, containing bilabiate flowers.

913. De Candolle made the following divisions, which are now pretty generally adopted:—1. Tubulifloræ, hermaphrodite flowers tubular, regularly 5- rarely 4-toothed. Under this section he included several tribes, in which the distinctions are founded on the nature of the style and stigma in the hermaphrodite flowers. These characters are shown in figs. 629-633, which illustrate the tribes Vernoniaceæ (fig. 633), Eupatoriaceæ (fig. 632), Asteroideæ (fig. 631), Senecionideæ (fig. 630), and Cynareæ (fig. 629). 2. Labiatifloræ, hermaphrodite flowers, or at least the unisexual ones, divided into two lips (fig. 625). The subdivisions of this section are also founded on the style and stigma (fig. 628). 3. Ligulifloræ (cichoraceæ), all the flowers hermaphrodite and ligulate (fig. 624). The form of the style and stigma is seen in fig. 627.

914. Henslow gives the following tabular view of these various divisions—the letter *l* meaning ligulate flowers; *f*, flosculous; H, hermaphrodite; F, female; N, neuter; M, male; the relative position of the letters indicating the nature of the florets in the circumference and in the centre of the same capitulum; and in the last three divisions, the letters having reference to the nature of the separate capitula:—

	Jussieu.	De Candolle.	
(*f. f. f.*)	Cynarocephalæ........................	Tubulifloræ	1.
(*l f. l.*)	Corymbiferæ...........................		
(*l. l. l.*)	Cichoraceæ	Ligulifloræ	3.
•	•	Labiatifloræ	2.

	Heads of Flowers.	Linnæan Orders.
(H. H. H.)	Homogamous..........................	Polygamia æqualis.
(F. H. F.)	Heterogamous..........................	———— superflua.
(N H. N.)		———— frustranea.
(F. M. F.)	Monœcious..............................	———— necessaria.
[(H.)]	Involucrate florets....................	———— segregata.
(M.)—(F.)	Diœcious................................	•
[(M.) (F.)]	Heterocephalous......................	•

915. The plants of this order are variously distributed over all quarters of the world. According to the calculations of Humboldt, they constitute $\frac{1}{7}$ of the phanerogamous plants of France, $\frac{1}{8}$ of Germany, $\frac{1}{13}$ of Lapland; in North America $\frac{1}{6}$, within the tropics of America $\frac{1}{6}$. Upon the authority of Brown, they only form $\frac{1}{16}$ of the Flora of the north of New Holland, and did not exceed $\frac{1}{25}$ in the collection of plants formed by Smith upon the western coast of Africa in Congo. In northern regions they are generally herbaceous, while in warm climates they sometimes become shrubby, or even arborescent. Cichoraceæ abound in cold regions, while Corymbiferæ are common in hot climates. The number of known genera amounts to upwards of 1000, comprehending 9500 or 10,000 species. They are considered as forming $\frac{1}{10}$ of the known species of plants, and this seems to have been the proportion at different periods. Thus, Linnæus enumerates 785 Compositæ out of 8500 species of plants then known all over the world.

	Compositæ.	Known Species in the World.
In 1809	2,800	27,000
1838	8,523	85,000
1846	9,500	95,000

Examples—Vernonia, Eupatorium, Aster, Bellis, Anthemis, Senecio, Centaurea, Carduus, Triptilion, Trixis, Cichorium, Hieracium, Sonchus.

916. The plants belonging to this vast order have all more or less bitterness, which is sometimes associated with astringent, acrid, and narcotic qualities.

Suborder *Cynarocephalæ.*—The plants of this suborder are usually tonic and stimulant. The bitterness of the plants of this section is often much lessened by cultivation, so that they become esculent. The root of *Arctium Lappa* (*majus* and *minus*), Burdock, is bitterish, and has been used in the form of infusion as a substitute for sarsaparilla. The root, leaves, and fruits (often called seeds), are diaphoretic, diuretic, and alterative. *Lappa edulis*, in Japan, supplies edible roots. *Aucklandia Costus*, found in Cashmere, is said to be the ancient costus, the root of which was celebrated for its virtues. It has an aromatic, pungent odour, and is used for incense. In northern India it is called Koosht; in Bengal, Puchak. The leaves of *Carduus Benedictus*, Blessed Thistle, were formerly used in medicine as a stomachic and diaphoretic. The blanched stems and leaf-stalks of *Cynara Cardunculus*, Cardoon, are eaten, and so are the young succulent receptacles of *Cynara Scolymus*, the Artichoke. The dried flowers of *Carthamus tinctorius* constitute Safflower, which yields a pink dye. The genus *Carduus* includes the various species of Thistle. What is denominated by gardeners the Scotch Thistle, is *Onopordum Acanthium*, a doubtful native of Scotland, but not uncommon in England.

917. Suborder *Corymbiferæ.*—The plants of this section have the general bitterness of the order, and some of them have an aromatic odour, from the presence of volatile oil. The flowers of *Anthemis nobilis*, Chamomile, are odoriferous, and yield a volatile oil, which is at first greenish or bluish, but afterwards yellowish brown. They are used as materials for fomentation, and an infusion of them acts as a diaphoretic and emetic. An extract is made from them, having bitter tonic qualities. The essential oil is an excellent carminative. *Anthemis tinctoria* supplies a yellow colour used for dyeing. *Pyrethrum Parthenium*, common Feverfew, is aromatic and stimulant. The root of *Anacyclus Pyrethrum*, Pellitory of Spain, or perhaps of *A. officinarum*, is an irritant and sialogogue; its properties depending on the presence of a volatile oil. *Tussilago Farfara*, Coltsfoot, has been used as a demulcent. The root of *Inula Helenium*, Elecampane, has stimulant and expectorant qualities. It contains a white amylaceous matter called Inulin. The species of *Artemisia* are remarkable for their strong odour and bitter taste. The heads of flowers of *Artemisia Absinthium* (*Absinthium officinale*, and *vulgare*), or Wormwood, and those of *Artemisia Santonica*, and of other species, under the name of Wormseed, are used as anthelmintics and tonics. Several of these species contain a crystalline bitter principle. *Artemisia mutellina*, and *spicata* are used in the preparation of a tincture or distilled spirit, called in France, Eau or Crême d'Absinthe, which is in request among those who are addicted to the pleasures of the table. The woolly leaves of *Artemisia Moxa* are used in China to form the inflammable cones or cylinders called Moxas, which are employed as counter-irritants. *Artemisia Dracunculus*, Tarragon, is used in pickles and salads, and in the medication of vinegar. *A. Abrotanum* is commonly called Southernwood, and is used on the continent in the preparation of beer. The leaves of *Tanacetum vulgare*, Tansy, have stimulant antispasmodic properties. They contain a bitter resin, and an aromatic volatile oil. *Arnica montana*, Mountain Tobacco, or Leopard's-bane, is an acrid stimulant. Its flowers, leaves, and root-stock, are administered in nervous diseases, as well as in gout and rheumatism. The seeds (properly fruits) of *Helianthus annuus*, common Sunflower, contain a bland oil, and when roasted they have been used as a substitute for Coffee. The name *Helianthus* (ἥλιος, the sun, and ἄνθος, a flower) is derived from the popular supposition, that its large heads of flowers follow the sun in its course (¶ 486). The roots of *Helianthus tube-*

rosus, Jerusalem, or more properly, Girasole Artichoke, are used as substitutes for potatoes. *Eupatorium Ayapana*, and *Mikania Guaco*, have been used to cure the bites of snakes. *Ceradia furcata* is a peculiar branching coral-like plant, which grows in dry sterile places in the south and west of Africa, and yields a resinoid substance, called by some African bdellium. *Madia sativa* has been cultivated on account of its bland oil. The species of *Lychnophora* give a peculiar feature to the mountains of Minas Geräes in Brazil. They grow like Vellozias, and they are covered with a dense coat of long brownish-coloured wool, which is often used for beds and pillows.

918. Suborder *Cichoraceæ*.—Most of the plants of this section yield a milky juice, which is bitter, astringent, and sometimes narcotic. By cultivation, some of them are rendered esculent. *Cichorium Intybus*, Wild Succory, or Chicory, is cultivated for the sake of its root, which is used as a substitute for, and as an addition to Coffee. The blanched leaves of *Cichorium Endivia* constitute Endive. *Taraxacum Dens Leonis* (or *officinale*), Dandelion, yields a milky juice, which, in the form of extract, has been used medicinally as a diuretic and alterative. It contains a bitter crystalline principle called Taraxacine. Its root is mixed with Coffee in the same way as Chicory. The inspissated juice of *Lactuca sativa*, common Lettuce, and of *L. virosa*, wild or strong-scented Lettuce, receives the name of Lactucarium, or Lettuce-opium, and is used medicinally for allaying pain, and inducing sleep. It contains a neutral active principle called Lactucin. Other species of Lactuca yield an inspissated juice having similar qualities. Scorzonera is the esculent root of *Scorzonera hispanica*, while Salsafy is the root of *Tragopogon porrifolius*, which is called the Oyster-plant in America. Many of the plants of the Cichoraceous section, such as *Hieracium*, *Sonchus*, and *Tragopogan*, act as horological and meteorological flowers (¶ 483, 484), their capitula opening and closing at certain periods of the day, and in different states of the weather.

919. Order 107.—**Brunoniaceæ**, the Brunonia Family. (*Monopet. Perigyn.*) Calyx persistent, 5-partite, with bracts at the base. Corolla inserted at the base of the calyx, monopetalous, nearly regular, withering; limb 5-parted, having central veins in its segments, which divide at the top into two recurrent marginal veins; æstivation valvate. Stamens 5, inserted with, but free from, the corolla, alternating with its segments; anthers articulated with the short filaments, dithecal, introrse, dehiscing longitudinally. Ovary free, unilocular; ovule solitary, erect, anatropal; style single; stigma enclosed in a 2-valved cup or indusium. Fruit a utricle, enclosed in the hardened calycine tube. Seed solitary, erect, exalbuminous; embryo straight; cotyledons fleshy, plano-convex; radicle minute, inferior.—Stemless herbaceous plants, with radical, exstipulate leaves, and capitate flowers, supported on scapes, and surrounded by an involucre of enlarged bracts. Natives of New Holland.

Their properties are unknown. The order contains as yet only 1 genus, and 2 species. *Example*—Brunonia.

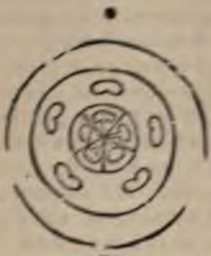
920. Order 108.—**Goodeniaceæ,** the Goodenia Family. (*Monopet. Epigyn.* and *Perigyn.*) Calyx persistent, usually equal, with 3-5 divisions, sometimes obsolete. Corolla inserted into the calyx, monopetalous, more or less irregular, marcescent or deciduous; its tube split at the back, and sometimes separable into five pieces, when the calyx only coheres with the base of the ovary; its limb 5-partite, uni- or bilabiate, the thin part of the segments being at the edges, which are folded inwards in æstivation. Stamens 5, distinct, inserted with, but free from, the corolla, and alternate with its segments; anthers not articulated with the filaments, distinct or cohering, bilocular, with longitudinal dehiscence; pollen-grains either separate or united in fours. Ovary more or less united to the calycine tube, 1-2- or 4-celled, sometimes with a gland at its base; ovules definite or 00, attached to a central, often free, placenta; style 1, simple, rarely divided; stigma fleshy, undivided or 2-lobed, surrounded by a cup-like indusium. Fruit a 1-2- or 4-celled capsule, or drupaceous or nut-like. Seeds definite or indefinite, with a thickened, often hard testa; embryo straight, in fleshy albumen; cotyledons leafy; radicle inferior.—Herbs, rarely shrubs, not lactescent, with scattered, exstipulate, usually alternate leaves, and distinct, never capitate flowers. They are found chiefly in Australia, and in the South Sea Islands. The leaves of *Scævola Taccada* are eaten as potherbs. Some superstitious qualities are ascribed to its berries. The pith, which is soft and spongy, is fashioned by the Malays into artificial flowers. *Scævola Bela-Modogam* appears to be emollient, and is used in India to bring tumours to a head. The order is divided into two suborders:—1. Goodenieæ, with dehiscent capsular fruit, and numerous seeds. 2. Scævoleæ, with indehiscent, drupaceous, or nut-like fruit, and seeds solitary, or two in each cell. There are 23 known genera, according to authors, and about 200 species. *Examples*—Goodenia, Velleia, Leschenaultia, Scævola, Dampiera.

921. Order 109.—**Stylidiaceæ,** the Stylidium or Stylewort Family. (*Monopet. Epigyn.*) Calyx adherent, persistent, with 2-6 divisions, bilabiate, or regular. Corolla gamopetalous, falling off late, limb usually irregular, 5-6-partite, segments with a central vein; æstivation imbricated. Stamens 2; filaments united with the style into a longitudinal column; anthers didymous, rarely simple, lying over the stigma; pollen simple, globose, or angular. Ovary cohering with the calyx, bilocular, or by contraction of the dissepiment unilocular, often surmounted by one gland in front, or by two opposite ones; ovules anatropal; style 1; stigma entire or bifid. Fruit a bivalvular, bilocular, or spuriously unilocular capsule, with septicidal dehiscence. Seeds 00, small, erect; embryo minute, enclosed in fleshy, somewhat

oily albumen.—Non-lactescent herbs or undershrubs, with alternate, scattered, or somewhat verticillate, entire, exstipulate leaves. They are well distinguished by their gynandrous structure. The column formed by the union of the filaments and style, possesses, in the species of the genus *Stylidium*, a peculiar irritability. It hangs down on one side of the flower, and when touched at the point of flexure, it springs over with considerable force from one side to the other. If not too far advanced to maturity, the column will recover its former position in the course of time. The flower may be cut off carefully without disturbing the column, and the irritability continues for a considerable length of time if the flower is put into water. The movement is said to be connected with the bursting of the anthers, and the discharge of the pollen on the stigma. The cause of this movement is very obscure, but it seems to depend on some changes in the cells (¶ 497, 665). The plants are principally natives of marshy places in New Holland. Some are found at the southern point of South America. There are 5 known genera, and 123 species. *Examples*—Stylidium, Forstera.

922. Order 110.—**Campanulaceæ,** the Hare-bell Family. (*Monopet. Epigyn.*) (Fig. 635.) Calyx superior, usually 5-lobed (figs. 636, 637 *c*), sometimes 3-8-lobed, persistent. Corolla gamopetalous; inserted into the top of the calyx, usually 5-lobed (fig. 255), sometimes 3-8-lobed, regular, marcescent (fig. 461 *e*); æstivation valvate (figs. 636, 637 *p*). Stamens inserted into the calyx, alternating with the corolline lobes, and equal to them in number; anthers bilocular, free (fig. 637 *e*); pollen spherical. Ovary more or less completely inferior, composed of two or more carpels; ovules indefinite (fig. 638); style simple, covered with collecting hairs (fig. 637); stigma naked, simple, or with as many lobes as there are ovarian cells (figs. 293 *s*, 637 *s*). Fruit capsular, crowned with the withered calyx and corolla, dehiscing in a loculicidal manner by lateral apertures (figs. 461 *t t*, 639), or by valves at the apex. Seeds 00, attached to a central placenta; embryo straight, in the axis of fleshy albumen; radicle pointing to the hilum (figs. 640-642).—Lactescent herbs or undershrubs, with alternate, rarely opposite, exstipulate leaves. The hairs on the style are said to be retractile, and seem to be connected with the application of the pollen (¶ 499). The flowers in most instances belong to the cyanic series. They are natives chiefly of northern and temperate regions. They abound in the alpine regions of Europe and Asia, and are also frequent in North America. Alphonse De Candolle states that the species whose capsule dehisces by lateral fissures are natives of the northern hemisphere, while those with apicilar dehiscence are principally found in the southern hemisphere. The milky juice found in the plants of this order has acrid properties. The roots and young shoots of *Campanula Rapunculus*, Rampion, are used as articles of diet. Authors enumerate

29 genera, including 536 species. *Examples*—Campanula, Phyteuma, Jasione.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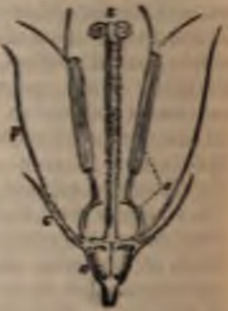

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923. Order 111.—**Lobeliaceæ**, the Lobelia Family. (*Monopet. Epigyn.*) Calyx superior, 5-lobed or entire. Corolla gamopetalous, inserted on the calyx, irregular, more or less deeply 5-cleft. Stamens 5, attached to the calyx, alternate with the segments of the corolla; anthers cohering; pollen oval. Ovary inferior, 1-3-celled; ovules 00, attached either to central or parietal placentas; style glabrous, with a fringe of hairs below the stigma. Fruit a 1- or many-celled capsule, with apicilar dehiscence. Seeds numerous; embryo straight, in the axis of fleshy albumen; radicle pointing to the hilum.—Lactescent herbs or shrubs, with alternate, exstipulate leaves. They are found both in temperate and warm countries. There are 29 known genera, and 386 species. *Examples*—Lobelia, Siphocampylus, Clintonia.

Figs. 635-642.—Organs of fructification of Campanula Rapunculus, Rampion, to illustrate the natural order Campanulaceæ.

Fig. 635.—Diagram of the flower, showing five divisions of the calyx, five divisions of the corolla alternating with them, five alternating stamens, and five cells of the ovary.

Fig. 636.—Flower-bud. *c*, Calyx adherent to the ovary. *p*, Corolla, with valvate æstivation.

Fig. 637.—Vertical section of the flower. *c*, Calyx cohering with the ovary, *o*. *p*, Gamopetalous corolla. *e*, Stamens with bilocular anthers. *s*, Lobed stigma at the apex of the style, which is covered with collecting hairs. *o*, Ovary containing numerous ovules attached to a central placenta.

Fig. 638.—Horizontal section of the ovary.

Fig. 639.—Fruit crowned by the limb of the calyx, dehiscing by openings at the base

Fig. 640.—Seed in an entire state.

Fig. 641.—Seed cut vertically. *p*, Perisperm (albumen). *e*, Straight embryo in the axis of the albumen, with the radicle pointing to the hilum.

Fig. 642.—Embryo detached, showing its form, the cotyledons and radicle.

924. Acridity prevails more or less in the order. The milky juice of some, such as *Lobelia urens*, is said to be vesicant. *Lobelia inflata*, Indian Tobacco, a native of North America, is used medicinally as a sedative, expectorant, and antispasmodic. It is chiefly administered in cases of asthma. The whole plant is active, but the root and capsules are said to be most powerful. In large doses, the plant acts as a narcotico-acrid poison. It owes its properties to a bitter principle called Lobelein. The root of *Lobelia syphilitica* is acrid and emetic. The milky juice of some of the plants of the order contains a considerable quantity of caoutchouc.

925. Order 112.—**Gesneraceæ**, the Gesnera Family. (*Monopet. Perigyn.*) Calyx partially adherent, 5-partite; æstivation valvate. Corolla monopetalous, tubular, more or less irregular, 5-lobed; æstivation imbricated. Stamens 4, didynamous, with the rudiment of a 5th, rarely 2; anthers dithecal, with a thick swollen connective. Ovary partly free, unilocular, formed by two carpels with parietal placentas, which are 2-lobed; ovules indefinite, anatropal; style continuous with the ovary; stigma capitate, concave, glandular or annular. Disk surrounding the base of the ovary. Fruit capsular or succulent, 1-celled, more or less adherent. Seeds 00, minute; testa thin, finely and obliquely veined; embryo erect in the axis of fleshy albumen; radicle pointing to the hilum.—Herbs or shrubs, often springing from scaly tubers, with opposite or whorled, rugose, exstipulate leaves and showy flowers. They are found principally in the warmer regions of America, and are interesting chiefly on account of their beauty, for they do not appear to possess any important qualities. There are 22 known genera, and upwards of 120 species. *Examples*—Gesnera, Columnea, Gloxinia, Achimenes.

926. Order 113.—**Styracaceæ** (Symplocineæ of Don), the Storax Family. (*Monopet. Perigyn.*) Calyx persistent, with an entire or a 5- or 4-divided limb. Corolla gamopetalous, regular, inserted in the calyx; æstivation imbricated or valvate. Stamens definite or 00, attached to the corolline tube, of unequal length; filaments often slightly united at their base in one or more parcels; anthers innate, dithecal, introrse. Ovary either free or cohering more or less to the calycine tube, 2-5-celled, the septa occasionally deficient towards the centre; ovules 2-4 in each cell or 00, pendulous, sometimes the upper ones ascending; style simple; stigma simple. Fruit enclosed in the calyx, drupaceous, usually unilocular by abortion. Seeds usually solitary, erect or suspended; embryo slender, in the axis of fleshy albumen; cotyledons flat, foliaceous; radicle long, pointing to the hilum.—Trees or shrubs, with alternate, exstipulate leaves, and frequently stellate hairs. They are chiefly natives of warm countries. There are two sections:—1. Styraceæ, with a more or less valvate æstivation of the corolla, and long anthers. 2. Symploceæ, with

a quincuncial corolline æstivation, and roundish anthers. Authors give 12 genera, including 130 species. *Examples*—Styrax, Halesia, Symplocos.

927. The plants of the order have in general stimulant, aromatic, and fragrant properties. *Styrax officinale*, a tree inhabiting Syria, Arabia, and the southern parts of Europe, is supposed to be the source of the balsamic resinous substance called Storax. The resinous juice is procured after incisions or punctures by insects. Common Storax is imported into Britain from Trieste, in the form of little cakes, having a balsamic odour. Besides resin and a little volatile oil, it contains from 1-2½ per cent of Benzoic acid. It has been employed medicinally as a pectoral remedy. *Styrax Benzoin* is a tree 70 or 80 feet high, a native of Sumatra and Borneo, which yields by incisions the concrete balsamic exudation called Benzoin. When fine, this substance contains about 80 per cent of resin, and nearly 20 of Benzoic acid. It is used medicinally as a stimulant expectorant, and is one of the ingredients in the celebrated Friar's balsam. It exists also in other empirical remedies, such as Riga balsam and Jesuits' drops. Benzoin is generally used for fumigation and incense. Pastilles are made by mixing it with balsam of tolu, sandal-wood, labdanum, charcoal, nitre, gum, and tragacanth. *Halesias* are the Snow-drop trees of Carolina. Some of the species of *Symplocos* are used for dyeing; others are used as tea.

928. Order 114.—**Columelliaceæ**, the Columellia Family. (*Monopet. Epigyn.*) Calyx superior, quinquepartite. Corolla rotate, inserted into the calyx, 5-8 parted; æstivation imbricate. Stamens 2, inserted in the throat of the corolla; anthers roundish, 3-lobed, extrorse, each consisting of six linear sinuous cells, arranged in pairs, dehiscing longitudinally, and attached to a 3-lobed fleshy connective. Disk fleshy, perigynous. Ovary adhering to the calycine tube, 2-celled; ovules 00; style simple, smooth; stigma capitate, 2-lobed. Fruit, a bilocular, bivalvular capsule, with both septicidal and loculicidal dehiscence. Seeds 00; testa smooth and coriaceous; embryo straight, in the axis of fleshy albumen; cotyledons oval, obtuse; radicle long, pointing to the hilum.—Evergreen shrubs or trees, with opposite, entire, exstipulate leaves, and solitary yellow flowers. Natives of Mexico and Peru. Their properties unknown. There is 1 genus mentioned, including 3 species. *Example*—Columellia.

929. Order 115.—**Vacciniaceæ**, the Cranberry Family. (*Monopet. Epigyn.*) Calyx superior, entire, 4-6-lobed. Corolla monopetalous, 4-6-lobed; æstivation imbricated. Stamens distinct, 8-12, inserted into an epigynous disk; anthers bilocular, with two horn-like cells, dehiscing by pores (fig. 335). Ovary inferior, 4-5-celled; ovules 00; style simple; stigma simple. Fruit succulent, crowned by the persistent limb of the calyx. Seeds 1 or many in each cell, minute; em-

bryo straight, in the axis of fleshy albumen; cotyledons very short; radicle long, inferior.—Shrubby plants, with alternate, undivided, exstipulate leaves. They are closely allied to Ericaceæ, and differ from that order chiefly in their adherent (inferior) ovary. They are natives of temperate regions, and some of them are marsh plants. Some are astringent, others yield subacid edible fruits. Cranberries are produced by *Vaccinium Oxycoccus* (*Oxycoccus palustris* of some), and *V. macrocarpum*. *V. Vitis-idæa*, red Whortleberry, or Cowberry, yields a fruit which is often used as a substitute for Cranberries. The leaves of the plant are sometimes used to adulterate Uva-Ursi. *V. uliginosum*, found in alpine countries, produces the black whortleberry. *Vaccinum Myrtillus* yields the Bilberry or Blaeberry. There are 28 genera and 210 species. *Examples*—Vaccinium, Oxycoccus, Thibaudia.

Subclass III.—COROLLIFLORÆ.

Calyx and corolla present. Corolla gamopetalous, hypogynous, usually bearing the stamens. It includes the hypogynous monopetalous and gamopetalous orders of Jussieu and Endlicher.

930. Order 116.—**Ericaceæ**, the Heath Family. (*Monopet. Hypog.*) Calyx 4-5-cleft, nearly equal, persistent. Corolla inserted at the base of the calyx, or hypogynous, monopetalous (fig. 298), 4-5-cleft, sometimes tetra- or pentapetalous, regular or irregular, often marcescent; æstivation imbricated. Stamens definite, equal in number to the segments of the corolla, or twice as many, inserted with the corolla, and either free from it or attached to its base; anthers 2-celled, cells hard and dry, bifid (fig. 336), usually having appendages at the base (fig. 338 *a*) or apex, dehiscing by apicilar pores (fig. 340) or clefts. Ovary free, surrounded at the base by a disk or scales, multilocular; ovules 00, attached to a central placenta; style 1, straight; stigma 1, undivided (fig. 408), or toothed. Fruit capsular or baccate, many-celled, with loculicidal or scepticidal dehiscence. Seeds 00, minute; embryo cylindrical, in the axis of fleshy albumen; radicle next the hilum.—Shrubs, undershrubs, or herbaceous plants, with evergreen, often rigid, entire, verticillate, or opposite, exstipulate leaves. The order contains many beautiful and showy plants, which abound at the Cape of Good Hope, and which are found also in Europe, North and South America, and Asia. The order has been divided into the following suborders:—1. Ericeæ, with the testa closely adherent to the kernel, including the true Heaths with naked buds, and the Rhododendron tribe with scaly conical buds. 2. Monotropeæ, seeds having a loose winged testa, including the true Monotropas or Fir-rapes, scaly plants, with longitudinally or transversely dehiscent anthers, and Pyroleæ, or the Wintergreen tribe, leafy plants with porous anthers. There are 54 known genera, and nearly 920 species. *Examples*—

Erica, Calluna, Menziesia, Andromeda, Arbutus, Rhododendron, Azalea, Monotropa, Pyrola.

931. The plants of the order are not distinguished for medicinal virtues. None of the species of *Erica* are put to any use. There are six species of the genus natives of Britain: two of which, *E. cinerea* and *E. Tetralix*, are common; two are peculiar to Ireland, *E. Mackaiana* and *E. mediterranea;* and two are common to England and Ireland, *E. ciliaris* and *E. vagans*. *Calluna vulgaris*, is Ling, or the common Heather. It has astringent qualities, and has been used for dyeing. It is commonly made into brooms. The leaves of *Arbutus*, or *Arctostaphylos Uva-Ursi*, Bearberry, are used as astringents, especially in chronic mucous discharges. Many of the species of *Rhododendron*, *Azalea*, *Kalmia*, *Andromeda*, and *Ledum*, have poisonous narcotic qualities. These properties are well marked in *Rhododendron Chrysanthum*, a Siberian species. It is said that *Azalea pontica* was the plant, the flowers of which yielded the poisonous honey, noticed by Xenophon in his account of the retreat of the 10,000. The fruits of many plants belonging to the order are eatable. *Gaultheria procumbens* and *Shallon* are American shrubs, which furnish succulent and grateful berries. They yield a volatile oil. *Arbutus Unedo* is called Strawberry-tree, from its fruit resembling a strawberry in aspect. It is, however, by no means agreeable as an article of food, and the specific name may possibly indicate, that to *eat one* is sufficient. The plant grows at the Lakes of Killarney in a native state. *Chimaphila* (*Pyrola*) *umbellata*, a North American plant, has been employed as a tonic and diuretic. The leaves have a bitter astringent taste, and the fresh plant is irritant.

932. Order 117.—**Epacridaceæ**, the Epacris Family. (*Monopet. Hypog.*) Calyx 5- rarely 4-parted, often coloured, persistent. Corolla inserted at the base of the calyx, or hypogynous, deciduous or marcescent, monopetalous, sometimes separable into 5 petals; limb with 5, rarely 4, equal divisions, sometimes by the cohesion of the segments, bursting transversely; æstivation imbricated or valvate. Stamens inserted with or on the corolla, equal in number to, and alternate with its segments, rarely fewer; anthers 1-celled (fig. 327), without appendages, opening longitudinally; pollen round, or formed of three united grains, attached to a single central receptacle. Ovary sessile, free, multilocular, rarely unilocular, surrounded by scales at the base; ovules solitary or 00; style 1; stigma simple, sometimes toothed. Fruit drupaceous, baccate, or capsular. Seeds albuminous; embryo slender, in the axis of fleshy albumen, and about half its length. —Shrubs, or small trees, with alternate, rarely opposite, exstipulate leaves, which are sometimes half-amplexicaul at the base. They are allied to Ericaceæ, and seem to occupy the place of heaths in Australia. They are distinguished from heaths by the structure of their anthers. Some yield edible fruits. One of the plants, called Native Currant

in Australia, is *Leucopogon Richei*. The order has been divided into two sections:—1. Epacreæ, polyspermous. 2. Styphelieæ, monospermous. There are 32 genera, and 336 species. *Examples*—Epacris, Sprengelia, Styphelia, Leucopogon, Lissanthe.

933. Order 118.—**Ebenaceæ**, the Ebony Family. (*Monopet. Hypog.*) Flowers hermaphrodite or unisexual. Calyx 3-7-divided, nearly equal, persistent. Corolla gamopetalous, regular, deciduous, somewhat coriaceous; limb with 3-7 divisions; æstivation imbricated. Stamens either attached to the corolla, or hypogynous, 2 or 4 times as many as the corolline segments, rarely equal to them in number, and then alternate with them; filaments usually in two rows, the inner row having smaller anthers; anthers erect, lanceolate, bilocular, with longitudinal dehiscence. Ovary free, sessile, multilocular; ovules 1-2 in each cell, pendulous; style divided, rarely simple; stigmas bifid or simple. Fruit fleshy, round or oval, the pericarp sometimes opening regularly. Seeds few; testa membranous; embryo straight, nearly in the axis of cartilaginous albumen; cotyledons leafy; radicle taper, next the hilum.—Trees or shrubs, not lactescent, with alternate, exstipulate, coriaceous leaves. They are chiefly found in tropical regions, and many species are met with in India. The plants are in general remarkable for the hardness and durability of their wood. Some yield edible fruit. *Diospyros Ebenus* and other African and Asiatic species, supply Ebony, which is the black duramen of the tree. Other species of *Diospyros* furnish Ironwood. *Diospyros virginiana*, the Persimmon, yields a fruit (sometimes called the Date-plum) which is austere when green, but becomes sweet and eatable when ripe, especially after being acted on by frost. Its bark has been employed as a febrifuge. *D. Kaki* is the Keg-fig of Japan, the fruit of which resembles a plum. *Diospyrus hirsuta*. and a variety of *D. Ebenaster*, supply the Coromandel or Calamander wood of Ceylon. Genera 12, species 175. *Examples*—Diospyros, Royena, Maba.

934. Order 119.—**Aquifoliaceæ** (Ilicineæ of some), the Holly Family. (*Monopet. Hypog.*) Sepals 4-6; æstivation imbricated. Corolla monopetalous, hypogynous, 4-6-parted; æstivation imbricate. Stamens inserted into the corolla, alternate with its segments, and equal to them in number; filaments straight; anthers adnate, bilocular, introrse. Disk 0. Ovary free, fleshy, somewhat truncate, 2-6-celled; ovules solitary, anatropal, pendulous from a cup-shaped funiculus; stigma nearly sessile, lobed. Fruit fleshy, indehiscent, with 2-6 monospermous nucules, and hence it is sometimes called a nuculanium (¶ 553). Seed suspended; albumen large, fleshy; embryo small, lying next the hilum; cotyledons small; radicle superior.—Evergreen trees or shrubs, with alternate or opposite, coriaceous, simple, exstipulate leaves. They are found in various parts of the world, as in Europe, North and South America, and Africa. Lindley enumerates 11 genera, including 110 species. *Examples*—Ilex, Prinos.

935. Astringent and tonic properties seem to pervade the order. *Ilex Aquifolium*, the common Holly, is a native of Europe, and is one of the indigenous plants of Britain. It forms excellent fences and hedges. At Tynningham, in Scotland, there are 2952 yards of holly hedges, most of them upwards of 130 years old. These hedges vary in height from 10 to 23 feet, and they are 9 to 13 feet wide at the base. The leaves and bark of the Holly are said to possess tonic and febrifuge properties; while its succulent fruit (berries) are emetic and purgative. Haller recommends the juice of the leaves in icterus. Its wood is white and hard, and is much esteemed in turnery, joinery and cabinet work, while its bark furnishes bird-lime. *Ilex Paraguayensis* furnishes Yerba Maté or Paraguay Tea, which is used extensively in some districts of South America. The leaves of the plant yield the bitter principle called Theine, which has been mentioned as existing in Tea and Coffee. Other species of *Ilex* are employed in Brazil for a similar purpose. The black drink of the Creek Indians is prepared from the leaves of *Ilex vomitoria*.

936. Order 120.—**Sapotaceæ**, the Sappodilla Family. (*Monopet. Hypog.*) Flowers hermaphrodite. Calyx regular, with 5, sometimes 4-8 divisions, persistent; æstivation valvate or imbricate. Corolla monopetalous, hypogynous, deciduous, regular, its lobes equal to, rarely twice or thrice as many as those of the calyx. Stamens inserted on the corolla, definite, distinct; fertile ones as many as, rarely more than, the segments of the calyx, with which they alternate; sterile ones alternating with the fertile ones, rarely wanting. Disk 0. Ovary free, multilocular; ovules solitary, anatropal, ascending or pendulous; style 1; stigma simple, sometimes lobed. Fruit fleshy, multilocular, or by abortion unilocular. Seeds nut-like, solitary; testa bony and shining, with a long scar on its inner face; embryo large, erect, white; albumen usually fleshy, sometimes 0; cotyledons in the albuminous seeds, foliaceous, in the exalbuminous, fleshy; radicle straight or slightly curved, pointing to the hilum.—Lactescent trees or shrubs, with alternate, exstipulate, entire, coriaceous leaves. They are natives chiefly of the tropical parts of India, Africa, and America. A few are found at the Cape of Good Hope. The number of known genera noticed by authors is 25, species 218. *Examples*—Chrysophyllum, Achras, Bassia, Isonandra, Mimusops.

937. Many of the plants of this order yield edible fruits, while others supply oily matter. Some act as tonics, astringents, and febrifuges. *Achras Sapota*, and other species, furnish the Sappodilla Plum and Naseberry, well known West Indian fruits; while *Achras mammosa* lds the fruit called Marmalade. The bark of some of the species of *hras* is tonic and astringent, and the seeds of several have laxative perties. The fruit of *Chrysophyllum Cainito* is the Star-apple. ther species of the genus supolics the Surinam Medlar of Euro-

peans. Various species of *Bassia* yield oil. *B. Parkii* is said to be the source of the Shea butter, and hence the tree is called the Butter-tree of Park. *B. butyracea*, the Madhuca tree, gives a similar product, which is used as butter in Nipal. The milky juice of some of the plants contains elastic matter. *Isonandra Gutta* is the source of Gutta Percha, a kind of caoutchouc, which softens at a moderate temperature, and is now extensively used for the soles of shoes, ropes, straps, casts, and various articles for domestic use. The kernels of *Lucuma mammosa* contain prussic acid.

938. Order 121.—**Myrsinaceæ**, the Myrsine Family. (*Monopet. Hypog.*) Flowers hermaphrodite or occasionally unisexual. Calyx 4-5-cleft, persistent. Corolla monopetalous, hypogynous, 4-5-cleft, equal. Stamens 4-5, inserted into the corolla, and opposite to its segments; filaments distinct, rarely united, sometimes 0, occasionally 5 sterile petaloid alternating ones; anthers sagittate, erect, bilocular, with longitudinal dehiscence. Ovary free or slightly adherent, unilocular; ovules definite or indefinite, campylotropal, immersed in a free central placenta; style single; stigma simple or lobed. Fruit fleshy, 1- or many-seeded. Seeds angular or roundish, with a concave hilum, and a membranous spermoderm; albumen horny; embryo usually curved, often heterotropal; cotyledons short; radicle horizontal when the seed is solitary, inferior when there are several seeds.—Trees, shrubs, or undershrubs, with alternate or opposite, coriaceous, exstipulate leaves. They are much restricted as regards their geographical limits, and they are said to abound chiefly in islands with an equable temperature. They are found in Africa, Asia, and America. Little is known regarding their properties. *Theophrasta Jussiæi* is a prickly-leaved shrub, which is called Coco in St. Domingo. Its seeds are eatable, and a kind of bread is made from them. The berries of *Myrsine bifaria* are said to possess cathartic properties. The *Ardisias* are prized for the beauty of their foliage. There are 33 known genera, and 337 species. *Examples*—Myrsine, Ardisia, Mæsa, Jacquinia.

939. Order 122.—**Jasminaceæ**, the Jasmine or Jessamine Family. (*Monopet. Hypog.*) Flowers ☿. Calyx with 5-8 divisions or teeth, persistent. Corolla monopetalous, hypogynous, regular, salver-shaped, with 5-8 divisions; æstivation twisted or valvate. Stamens 2, inserted on the corolla, included; anthers bilocular, with longitudinal dehiscence. Disk 0. Ovary free, 2-celled; ovules erect, anatropal, 1-4 in each cell; style 1; stigma 2-lobed. Fruit a double berry, or a pyxidium, or a 2-valved capsule. Seeds usually solitary, rarely in pairs, albuminous or exalbuminous; embryo straight; radicle inferior.—Shrubs often with twining stems, and opposite or alternate, pinnate leaves. They abound chiefly in the tropical parts of India. They have frequently fragrant flowers which yield oils, and their leaves and roots are sometimes bitter. The essential oil of Jasmine is procured from *Jasminum*

officinale, *grandiflorum*, *odoratissimum*, and *Sambac*. The bitter root of *Jasminum angustifolium*, ground small and mixed with powdered Acorus Calamus root, is considered in India as a valuable external application in cases of ringworm. In the East Indies the tube of the corolla of *Nyctanthes Arbor-tristis* is used as an orange dye. There are 6 known genera, and 110 species. *Examples*—Jasminum, Nyctanthes, Bolivaria.

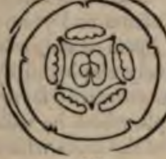
940. Order 123.—**Oleaceæ**, the Olive Family. (*Monopet. Hypog.*) (Fig. 254.) Flowers ☿, sometimes ♂ ♀. Calyx gamosepalous, divided, persistent. Corolla gamopetalous, hypogynous, 4-cleft, sometimes of 4 petals, which are connected in pairs by means of the filaments, sometimes 0, æstivation somewhat valvate. Stamens 2 (rarely 4), alternate with the corolline segments; anthers dithecal, with longitudinal dehiscence. Disk 0. Ovary free, 2-celled; ovules in pairs, collateral or pendulous; style 1 or 0; stigma entire or bifid. Fruit drupaceous, baccate or capsular, sometimes samaroid (fig. 437). Seeds often by abortion solitary; albumen dense, fleshy, abundant; embryo straight, about half the length of the albumen; cotyledons leafy; radicle superior.—Trees or shrubs, with opposite leaves (fig. 254), which are either simple or compound. Found chiefly in temperate regions. They occur in North America, Asia, Europe, and New Holland. There are two sections of the order:—1. Oleæ, with a drupaceous or berried fruit. 2. Fraxineæ, with a samaroid (winged) fruit. Lindley mentions 26 genera, including 144 species. *Examples*—Olea, Ligustrum, Fraxinus, Syringa.

941. The plants of the order are bitter, tonic, and astringent, and some yield fixed oil. *Olea europæa* is the Olive-tree, the זַיִת of the Bible, the ἐλαία of the Greeks. It grows naturally on the coast of the Mediterranean, and is cultivated in many parts of the south of Europe. There are several varieties of the plant, two of which have been long distinguished—the wild and cultivated. The former is an evergreen shrub or low tree, with spiny branches and round twigs; the latter is a taller tree, without spines, and with four-angled twigs. The fruit is a drupe, about the size and colour of a damson. Its fleshy pericarp yields by expression olive oil, of which the finest comes from Provence and Florence. It consists of two oleaginous principles—Margarin and Elain. Olive oil has nutrient, emollient, and laxative properties. It is used in forming ointments, liniments, and plasters. The bark of the Olive-tree has been used as a tonic; and a resinous exudation from it, called Olivile, or Olive-gum, or Lecca-gum, is employed in the same way. Spanish or Castile soap is made by mixing olive oil and soda, while soft soap is made by mixing the oil with potash. The flowers of *Olea fragrans*, the Lan-hoa of the Chinese, are used to perfume teas. Several species of *Ornus*, more particularly *O. rotundifolia* and *O. europæa*, yield a sweet exudation called Manna, a substance completely different from the מָן (manna) of the Bible, on

which the Israelites fed. The Manna or Flowering Ash is a native of southern Europe, and grows abundantly in the south of Italy and in Sicily, whence the Manna of commerce is imported. The tree attains a height of 20 or 30 feet, and it has a fine appearance when its clusters of white flowers are produced. There is a very fine Manna-ash in the Edinburgh Botanic Garden. Manna is the concrete juice of the tree, which flows out after incisions or insect-punctures. It contains a peculiar sweet principle called Mannite. Manna is nutritive and laxative, and is sometimes administered to infants and young children, on account of the mildness of its action. *Syringa vulgaris*, common Lilac, has a febrifuge bark, which is extensively employed by the peasants in Brenne, for the cure of the endemic intermittent fever. According to Meillet this quality is owing to a principle which he calls Lilacine. *Fraxinus excelsior*, the common Ash, is one of the trees which comes late into leaf, and the leaves of which fall off early in autumn. Some specimens attain the height of 70, 90, or 100 feet, with a circumference of 20 or 30 feet. The wood of the tree is tough and elastic, and is used for oars, as well as by coachmakers, &c. The wood of its roots is beautifully veined. The pendulous variety, called Weeping-ash, is often engrafted on the common Ash, so as to produce a better effect. The leaves of *Ligustrum vulgare*, common Privet (fig. 254), are astringent. *L. lucidum* yields a kind of waxy excretion, which is used in China for economical purposes.

942. Order 124.—**Asclepiadaceæ,** the Asclepias Family. (*Monopet. Hypog.*) (Figs. 353, 643-651). Calyx 5-divided, persistent (fig. 646 *c*.) Corolla synpetalous (monopetalous), hypogynous, regular, 5-lobed (figs. 644, 645 *p p*), deciduous; æstivation imbricate, rarely valvate. Stamens 5, inserted into the base of the corolla, and alternate with its segments (fig. 646 *e*); filaments usually combined so as to form a tube; staminal tube rarely naked behind, generally furnished with a corona (crown) of variously-formed leaves, which are either distinct or connate. Anthers bilocular, each cell sometimes spuriously divided; pollen, when the anther dehisces, cohering in masses (pollinia), which are either as numerous as the cells, or are confluent in pairs, and adhere to the five stigmatic processes, either in sets of two or four, or singly (figs. 349, 353, 647). Ovaries 2 (fig. 646 *o*); ovules 00; styles 2, closely approaching each other (fig. 646 *s*), often very short; stigma common to both styles, dilated, quinquangular; the angles furnished with cartilaginous corpuscles which retain the pollinia, or with glands (figs. 645, 646 *g*). Fruit consisting of two follicles (sometimes only one by abortion) having a placenta on the ventral suture (fig. 649). Seeds 00, imbricate, pendulous, usually comose (hairy) at the hilum (fig. 650); albumen thin (fig. 651 *p*); embryo straight; cotyledons leafy; radicle superior (fig. 651 *e*).—Shrubs, or occasionally herbs, usually with milky juice,

and often twining. The leaves are usually opposite, sometimes alternate or verticillate, with interpetiolary cilia in place of stipules.



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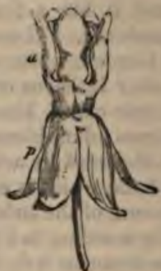

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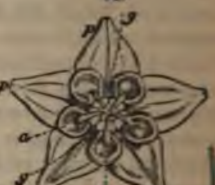

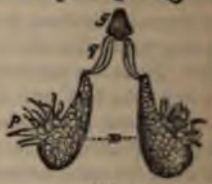

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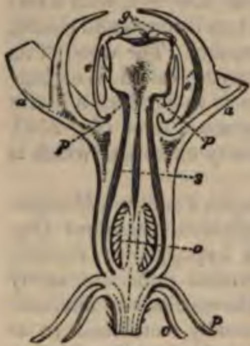

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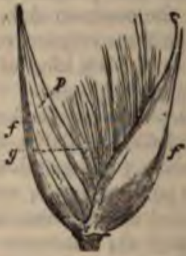

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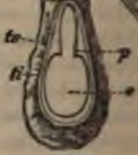

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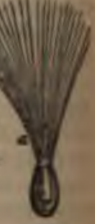


650

The gynostegium (γυνὴ, pistil, and στέγω, I cover), staminal crown

Figs. 643-651.—Organs of fructification of Asclepias nivea, to illustrate the natural order Asclepiadaceæ.

Fig. 643.—Diagram of the flower, with five divisions of the calyx, five segments of the corolla, five stamens, and two ovaries.

Fig. 644.—The entire flower. *p*, Corolla, with five lobes. *a*, Appendages forming the staminal crown (corona).

Fig. 645.—The flower viewed from above. *p p*, Gamopetalous corolla with its five lobes. *a a*, Appendages forming the corona or crown. *g g*, Glandular bodies attached to the stigma and bearing the pollen-masses (pollinia).

Fig. 646.—The flower cut vertically. *c*, Calyx. *p*, Corolla. *a a*, Coronal appendages. *s*, Stamens. *o*, Ovary. *s*, Styles which are united at the upper part by means of the large stigma, at the base of which, towards the points, *p p*, the pollen tubes enter.

Fig. 647.—Two pollen-masses, *m*, attached by two prolongations, *q*, in the form of a caudicle or tail, to another body, *g*, formed by the union of two stigmatic glands. *p*, Pollen-grains with tubes beginning to escape from the masses.

Fig. 648.—One of the pollen-grains, with its tube separated and highly magnified.

Fig. 649.—Fruit at the period of dehiscence. *f f*, Two follicles. *p*, Placenta, which is detached. *g*, Comose seeds.

Fig. 650.—One of the comose seeds separated. *a*, The hairy appendage at the hilum.

Fig. 651.—Seed separated from the hairs and cut vertically. *t e*, External integument. *t i*, Internal integument. *p*, Perisperm or thin albumen. *e*, Embryo, with leafy cotyledons and superior radicle.

peculiar-hooded (cucullate) appendages, prolonged from the tube
the filaments, which occur in many of the plants of this order,
e a peculiar aspect to their flower (see fig. 353). They inhabit
efly warm and tropical regions, but many species extend to
rthern climates. Many succulent species are found in the south of
rica. In tropical India and New Holland, and in all the equi-
ctial parts of America, they also abound. Authors enumerate
9 genera, including 958 species. *Examples*—Periploca, Asclepias,
lotropis, Cynanchum, Gonolobus, Stapelia, Hoya, Dischidia.

943. The plants of the order have acrid, purgative, emetic, and
phoretic properties. The milky juice is usually bitter and acrid,
occasionally it is bland, and is used as milk, as in the case of
mnema lactiferum, the Cow-plant of Ceylon. *Asclepias tuberosa*, the
tterfly-weed, or Pleurisy-root, is used as a cathartic and diaphoretic
North America. The emetic properties of *Asclepias curassavica*
e secured for it the name of Wild Ipecacuanha, in the West Indies.
e leaves of *Solenostemma* (*Cynanchum*) *Argel*, are used to adulterate
exandrian Senna. The fragrant roots of *Hemidesmus indicus* are
d in Madras as a substitute for Sarsaparilla, under the name of
untry Sarza. The bark of the root of several species of *Calotropis*,
h as *C. procera*, *Hamiltonii*, and *gigantea*, furnish the substance
led Mudar, which is used as a diaphoretic in India. It contains a
nciple called Mudarine, which gelatinizes on being heated, and
omes fluid on cooling. *Cynanchum monspeliacum* furnishes
ntpellier Scammony, and *Periploca mauritiana* is the source of
urbon Scammony. Both of these substances act as purgatives, and
used to adulterate true Scammony. *Marsdenia tinctoria* and
mnema tingens are said to yield a dye similar to indigo. The milky
ce of many of the plants contains caoutchouc in its composition. *Hoya*
nosa receives the name of wax-flower from the peculiar aspect of
blossoms. *Dischidia Rafflesiana*, an Indian climber, has remarkable
idia (¶ 164). The *Stapelias* are singular plants, resembling some
he Cactuses and Euphorbias. Their blossoms are often very fetid,
l hence they are called Carrion flowers. Some of the species of *Ascle-*
s receive the name of Wild Cotton, on account of the hairs attached
heir seeds. *Gomphocarpus fruticosus* is the silk-plant of Madeira.

44. Order 125.—**Apocynaceæ**, the Dogbane Family. (*Monopet.*
pog.) Calyx usually 5-partite, persistent. Corolla hypogynous,
opetalous, regular, usually 5-lobed, deciduous; æstivation con-
ed, twisting in some cases to the right, in others to the left. Sta-
s 5, inserted on the corolla, alternate with its segments; filaments
inct; anthers 2-celled, dehiscing longitudinally; pollen granular,
ose, or 3-lobed, immediately applied to the stigma. Ovaries 2,
each unilocular, or one, and bilocular; ovules 00; styles 2 or 1;
ma 1, with a contraction in the middle. Fruit follicular or capsu-

lar, or drupaceous or baccate, double or single. Seeds 00, rarely definite, usually pendulous; albumen cartilaginous or fleshy, rarely 0; embryo foliaceous; radicle turned towards the hilum.—Trees or shrubs, usually lactescent, with entire, generally opposite, exstipulate leaves, with interpetiolary cilia or glands. They are chiefly found in tropical regions. They appear to be most abundant in the hot parts of Asia, are less common in the tropics of America, and still less abundant in Africa. Authors enumerate 110 genera, including 602 species. *Examples*—Apocynum, Echites, Nerium, Balfouria, Vinca, Tanghinia, Plumieria, Carissa.

945. Many of the plants of this order are poisonous. Some are used medicinally, as cathartics, and there are a few which yield edible fruits. The order is in general to be regarded with suspicion. One of the most deadly plants of the order is *Tanghinia venenata* (*Cerbera Tanghin*), the seeds of which supply the famous Tanghin poison, used formerly in Madagascar as an ordeal in cases of criminals. *Nerium Oleander*, the common Oleander, is poisonous. The stomata of its leaves are formed by means of cellular hair-like processes (fig. 76), and the anthers are terminated by feathery appendages (fig. 334). Death has ensued from eating the flowers of this plant. Its branches, when divested of their bark and used as skewers, rendered meat roasted on them poisonous. The meat proved fatal to seven out of twelve of those who partook of it. The roots of *Apocynum cannabinum* and *androsæmifolium* are said to be emetic. The *Vincas*, Periwinkles, are astringent and acrid. *Allamanda cathartica*, a native of Ceylon and Java, is emetic and cathartic. Although the milky juice is generally acrid, still in some instances it is bland. Thus, the juice of *Tabernæmontana utilis*, Hya-hya, the Cow-tree or Milk-tree of Demerara, is used as milk. Many of the plants, such as *Urceola elastica* and *Vahea gummifera*, supply caoutchouc. *Wrightia tinctoria* yields a dye like indigo. *Aspidosperma excelsum* is a Guiana tree, remarkable for the sinuous arrangement of its wood, which gives the stem a deeply-fluted appearance.

946. Order 126.—**Loganiaceæ**, the Logania Family (*Monopet. Hypog.*) Calyx 4-5-partite (fig. 287 *c*); æstivation valvate or imbricate. Corolla hypogynous, regular or irregular, 4-5- or 10-divided (fig. 287 *t l*); æstivation convolute or valvate. Stamens inserted on the corolla, 5 or 1, not always corresponding with the divisions of the corolla; pollen elliptical or triangular, simple, or marked with three bands. Ovary free, usually 2-celled; ovules 00 or solitary, peltate and amphitropal, or ascending and anatropal. Fruit a 2-celled capsule, with placentas finally becoming loose; or a nuculanium with 1 or 2-seeded nucules; or baccate, with seeds immersed in a pulp. Seeds usually peltate, sometimes winged; albumen fleshy or cartilaginous; embryo small; radicle turned towards the hilum, or parallel

with it.—Shrubs, herbs, or trees, with opposite entire leaves, and usually with stipules, which adhere to the footstalks, or form interpetiolary sheaths. They inhabit chiefly tropical and warm climates. The order is divided into three suborders:—1. Loganieæ, æstivation of corolla convolute, fruit a bilocular capsule or nuculanium, seeds peltate, sometimes winged. 2. Strychneæ, æstivation of corolla valvate, fruit a 2-3-celled berry or capsule, seeds peltate, embryo rather large. 3. Spigelieæ, æstivation of corolla valvate, fruit a didymous capsule, seeds apterous, embryo small, cotyledons inconspicuous. There are about 32 known genera, and nearly 190 species. *Examples*—Logania, Potalia, Strychnos, Spigelia.

947. The plants of this order are highly poisonous. They act energetically on the spinal marrow, causing tetanic spasms, or they produce narcotic symptons by acting on the brain. Many are very bitter and a few are tonic. *Strychnos Nux-Vomica*, the Poison-nut or Koochla, a tree which abounds on the Malabar and Coromandel coasts, supplies the substance called Nux-Vomica. It yields fruit of the size and appearance of an orange, with a coriaceous reddish integument, enclosing a mucilaginous pulp. The seeds, which are embedded in the pulp, are the officinal part of the plant. They are circular and flat, umbilicated on one surface, and are thickly covered with brown silky hairs. All parts of the plant, especially the seeds and bark, are intensely bitter. The seeds contain two alkaloids, Strychnia and Brucia, to which they owe their poisonons properties. These alkaloids occur in combination with Igasuric or Strychnic acid. Nux-Vomica and Strychnia, in poisonous doses, cause death by producing tetanic spasms in the muscles of respiration. The bark of the Nux-Vomica tree is the false Angustura bark, and the wood is often called Snake-wood. Strychnia exists in other species of *Strychnos*, as *S. Ignatia* (*Ignatia amara*), St. Ignatius's Bean, *S. colubrina*, and *S. ligustrina*, Snake-wood, *S. Tieuté*, the source of a Java poison called Upas Tieuté. It is also said to exist in the Woorali or Ourari poison of Guiana, which some consider to be the produce of *S. toxicaria* or *guianensis*. The effects of this last mentioned poison, however, do not seem to agree with those of Strychnia. Strychnia stimulates the spinal cord without affecting the function of the brain. It causes convulsive twitches of the muscles of the arms and legs, and hence it has been recommended in cases of chronic palsy, unconnected with any signs of local irritation or determination of blood to the head. Its administration requires great caution, as $\frac{2}{3}$ of a grain have been known to produce alarming lock-jaw, and $\frac{1}{6}$ of a grain has killed a dog. Some species of Strychnos seem not to possess a poisonous principle in large quantity, for they are used as tonics and febrifuges. Among them may be noticed *Strychnos potatorum* and *pseudoquina*. The former is called Clearing-nut, and is used in India for purifying water. The

root of *Spigelia marilandica*, Carolina Pink-root (fig. 287), is used as an anthelmintic, more particularly in the United States. *S. Anthelmia*, Guiana Pink-root, is employed in Demerara for a similar purpose. These plants also possess narcotic qualities.

948. Order 127.—**Gentianaceæ**, the Gentian Family. (*Monopet. Hypog.*) (See fig. 248.) Calyx gamosepalous, usually in 5 divisions, sometimes 4-6-8 or 10 divisions, persistent. Corolla gamopetalous, hypogynous, usually regular and marcescent; limb sometimes fringed, divided into as many lobes as the calyx; æstivation plaited or imbricate-twisted. Stamens inserted upon the corolla, alternate with its segments, and equal to them in number, some of them occasionally abortive. Ovary composed of 2 carpels, unilocular or partially bilocular (fig. 389); ovules 00, anatropal; style 1, continuous; stigmas 1 or 2. Fruit capsular or baccate, 1-celled (fig. 389), usually bivalvular, with septicidal, or rarely loculicidal dehiscence. Seeds 00, small, embryo straight, minute, in the axis of soft fleshy albumen; radicle next the hilum.—Herbs, seldom shrubs, with opposite (fig. 248), rarely alternate, entire or divided, exstipulate leaves, which are often 3-5-ribbed. The plants of the order are distributed generally over the globe, inhabiting both cold and warm regions. They are rare in the arctic and antarctic islands. They exhibit great varieties of colours, and many are prized for their beauty. There are two suborders:—1. Gentianeæ, æstivation of corolla imbricate-twisted, leaves opposite, simple, and entire. 2. Menyantheæ, æstivation of corolla plaited or induplicate, leaves usually alternate and compound, or divided. Authors mention 67 genera, including 484 species. *Examples*—Gentiana, Chironia, Agathotes, Erythræa, Chlora, Menyanthes, Villarsia.

949. The general property of the plants of this order is bitterness, which pervades all their organs. Hence they are used as tonics. The medicinal gentian is the root of *Gentiana lutea*, a plant which grows abundantly on the Pyrenees, and on the Alps of Switzerland and Austria, usually at an elevation of 3000 to 5000 feet. It produces showy yellow flowers, and its root is yellow internally. It is administered in the form of extract, infusion, tincture, and wine, as a tonic. Its roots are often mixed with the roots of other species, such as *Gentiana punctata*, *purpurea*, and *pannonica*. *Gentiana Kurroo* of the Himalayas has similar properties. The British species, *Gentiana campestris* and *Amarella*, have also been used as bitter tonics. The officinal Chiretta is the herb and root of *Agathotes Chirayta* (*Ophelia Chirata*), a herbaceous plant found in the Himalayas. The whole plant is bitter, and has been long used in Bengal as a tonic and stomachic. The flowering cymes of *Erythræa Centaurium*, common Centaury (fig. 248), are used as a substitute for gentian, and so are the leaves of *Menyanthes trifoliata*, Buck-bean, Marsh-trefoil, or Bog-

bean. The roots of *Frasera Walteri* sometimes receive the name of American Calumba.

950. Order 128—**Bignoniaceæ**, the Trumpet-Flower Family. (*Monopet. Hypog.*) Calyx divided or entire, sometimes spathaceous. Corolla monopetalous, hypogynous, usually irregular, 4-5-lobed. Stamens 5 and unequal, or 4 and didynamous, some of them occasionally sterile; anthers bilocular. Disk annular or glandular. Ovary superior, 1-2-celled, each cell being often spuriously divided; ovules indefinite; style 1; stigma bilamellar (fig. 406), or 2-4-cleft or entire. Fruit a 2-celled (sometimes spuriously 4-celled) and 2-valved capsule, occasionally succulent. Placentas parietal, sometimes extending to the centre, and forming a spurious dissepiment, which finally separates, bearing the seeds. Seeds winged or wingless, often flat and compressed, exalbuminous; embryo straight; radicle next the hilum.—Trees, shrubs, or herbs, with opposite, rarely alternate, exstipulate leaves. They abound generally in tropical regions, but some of them are widely distributed. The order has been divided into four sub-orders:—1. Bignonieæ, capsule 2-valved, 2-celled, sometimes spuriously 4-celled, with a dissepiment parallel or contrary to the valves, at length free, bearing the seeds, which are transverse, compressed, and winged. 2. Cyrtandreæ (Didymocarpeæ), fruit succulent or capsular, or siliquose and 2-valved, seeds small, ovate, or cylindrical, suspended, apterous, sometimes comose. 3. Crescentieæ, fruit woody, and melon-shaped, enclosing large seeds, which are immersed in the pulp of the placentas. 4. Pedalieæ, fruit drupaceous, rarely capsular and 2-valved, spuriously many-celled; seeds few, large and apterous, pendulous, erect or transverse. These are reckoned separate orders by many. There are upwards of 100 known genera, and about 666 species. *Examples*—Bignonia, Spathodea, Eccremocarpus, Cyrtandra, Didymocarpus, Crescentia, Pedalium, Sesamum.

951. There are many showy plants in this order. Their flowers are frequently large and trumpet-shaped. None of them are noted for marked medicinal properties. Some are timber trees, others furnish dyes and articles of diet, while a few have bitter and astringent qualities. The species of *Bignonia* are conspicuous objects in tropical forests. Their wood sometimes exhibits a crucial arrangement (fig. 107.) From *Bignonia Chica* the Indians extract a red ochreous colouring matter, with which they paint their bodies. *Crescentia Cujete*, the Calabash-tree, is found in the tropical regions of America, and produces a large melon-like fruit, containing a slightly acid pulp, which is sometimes eaten. Its pericarp is hard, and after removal of the pulp it is used as cups and bottles. Teel seeds, the produce of *Sesamum orientale*, supply a bland oil, called by the Arabs Siritch. It is used under the name of gingilee oil to adulterate oil of almonds. The fruit of the species of *Uncaria* and *Martynia*, the Unicorn-plant, is furnished

with hooked processes. In the perfect fruit of *Pretrea* (*Martynia*) *Zanguebarica*, there are 6 cells formed by the mode in which the placentas unite, and of these cells two are seedless.

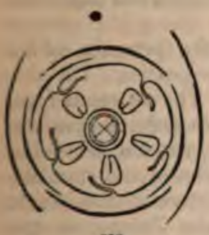
952. Order 129.—**Polemoniaceæ**, the Phlox Family. (*Monopet. Hypog.*) Calyx inferior, in 5 divisions, persistent, sometimes irregular. Corolla regular, rarely irregular, 5-lobed. Stamens 5, inserted on the middle of the tube of the corolla, and alternate with its segments; pollen often blue. Disk lobed. Ovary free, 3-celled; ovules anatropal or amphitropal; style simple; stigma trifid. Fruit a 3-celled, 3-valved capsule, with septifragal dehiscence. Seeds angular or oval, or winged, often enveloped in mucus, containing spiral threads, ascending, in a single or a double row; embryo straight, in the axis of a fleshy or horny albumen; cotyledons foliaceous, elliptical or cordate; radicle inferior, next the hilum.—Herbaceous or climbing plants, with opposite or alternate, simple or compound leaves. They inhabit temperate countries chiefly, and they abound in the north-western part of America. There are 17 genera enumerated by Lindley, including 116 species. *Examples*—Polemonium, Phlox, Cobæa (fig. 318), Collomia, Gillia, Leptosiphon, Cantua.

953. Many of the plants of this order have showy flowers, and are commonly cultivated in flower-borders. Connected with the episperm of various species of *Collomia* are numerous spiral cells, and when the seeds are moistened with water, the mucus surrounding the cells is dissolved, so that the spiral fibres are uncoiled. The movements of these fibres, when uncoiling, are beautifully seen under the microscope. The fibres carry with them a mucous envelope which has the appearance of a membrane. *Polemonium cœruleum*, Greek Valerian, or Jacob's ladder, is bitter. In Siberia, poultices are prepared from its leaves. The Russians fancy that a decoction of it is useful in hydrophobia.

954. Order 130.—**Hydrophyllaceæ**, the Hydrophyllum Family. (*Monopet. Hypog.*) Calyx 5-parted, persistent. Corolla monopetalous, hypogynous, regular, 5-cleft; æstivation plicate or imbricate. Stamens 5, inserted upon the corolla, and alternate with its segments; filaments sometimes petaloid; anthers deeply-lobed at the base, often versatile, 2-celled, dehiscing longitudinally or transversely. Disk annular or 0. Ovary free, 1-2-3-celled; ovules definite or indefinite; style 1 or 2; stigmas usually 2. Fruit capsular, 2-valved, 1-2-celled, with a parietal, or a large central placenta. Seeds with a brittle or reticulated testa; embryo in the midst of fleshy or cartilaginous albumen; radicle next the hilum.—Trees, shrubs, or herbs, with opposite, or alternate, exstipulate, often lobed leaves. They occur both in the northern and southern parts of America chiefly. They have no properties of importance. Many have showy flowers, and some have glandular or stinging hairs. The order has been divided into two suborders:—1. Hydrophylleæ, including Hydroleæ of authors, with the anthers

dehiscing longitudinally, disk present, ovary 1-2-celled, styles 2. 2. Diapensieæ, with anthers dehiscing transversely, disk 0, ovary 3-celled, style single. There are 20 known genera, and 81 species. *Examples* — Hydrophyllum, Hydrolea, Nemophila, Phacelia, Diapensia.

955.—Order 131.—**Convolvulaceæ,** the Convolvulus or Bindweed Family. (*Monopet. Hypog.*) Calyx in five divisions, persistent, imbricated, often bracteated (figs. 652-654). Corolla monopetalous, hypogynous, deciduous, regular; limb 5-lobed, with a plaited or imbricated æstivation (fig. 653 *p*); tube sometimes with scales, alternate with the lobes of the limb. Stamens 5, inserted in the base of the corolla, and alternate with its lobes (fig. 654 *e*). Disk annular,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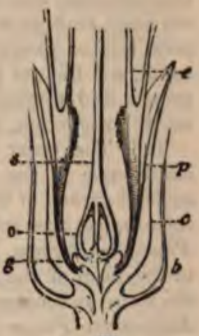

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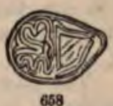
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Figs. 652-659.—Organs of fructification of Convolvulus (Calystegia) sepium, to illustrate the natural order Convolvulaceæ.

Fig. 652.—Diagram of the flower, showing two bracts, five unequal divisions of the imbricated calyx, five lobes of the plicate corolla, five stamens alternating with the corolline lobes, and a quadrilocular ovary.

Fig. 653.—Flower bud. *b*, Large bracts. *c*, Calyx. *p*, Corolla.

Fig. 654.—Vertical section of the lower part of the flower. *b*, Bracts. *c*, Calyx. *p*, Tube of corolla, bearing the filaments of the stamens, *e*. *o*, Ovary. *s*, Style.

Fig. 655.—Summit of the style and stigmas.

Fig. 656.—Fruit, *f*, surrounded by the calyx, *c*, and the bracts, *b*, which are persistent.

Fig. 657.—Seed. *h*, Hilum.

Fig. 658.—Section of the seed showing the corrugated cotyledons.

Fig. 659.—Embryo separated.

hypogynous. Ovary free, 2-4-celled, rarely by abortion 1-celled; ovules definite, erect, when more than one, collateral; style 1 (fig. 654 *s*), usually bifid, rarely 2; stigmas obtuse or acute (fig. 655). Fruit succulent or capsular (fig. 656), 1-4-celled, with septifragal and septicidal, or circumscissile dehiscence. Seeds albuminous; embryo curved or spiral (figs. 659, 502); cotyledons corrugated (fig. 658) or inconspicuous; radicle inferior.—Herbs or shrubs, usually twining, sometimes parasitical, often with a milky juice, and with alternate, undivided or lobed, exstipulate leaves, rarely leafless. They occur chiefly in tropical and temperate regions. A few only are found in cold climates. The order has been divided into two suborders:—1. Convolvuleæ, true Bindweeds, leafy plants, with the coralline tube not scaly, embryo curved, cotyledons conspicuous. 2. Cuscuteæ, Dodders, leafless parasites, having scales on the coralline tube, embryo spiral, and filiform (fig. 502), cotyledons inconspicuous. There are 51 genera, and upwards of 740 species. *Examples*—Convolvulus, Ipomœa, Exogonium, Dichondra, Cuscuta.

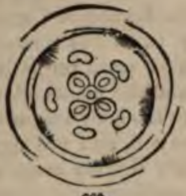
956. The order is characterized generally by the presence of an acrid juice in the roots, which has purgative properties. On this account several of the plants are used medicinally. The old genus *Convolvulus* has been split into various genera; such as *Ipomœa, Exogonium, Pharbitis, Batatas, Quamoclit, Calonyction,* and *Lepistemon*, according to the form of the corolla, the exsertion or inclusion of the stamens, the form and nature of the stigma, and the structure of the ovary. *Exogonium Purga* (*Ipomœa Purga*, or *Convolvulus Jalapa*) is the Jalap plant, a native of Mexico, which grows well in this country, requiring only the protection of a frame during winter. The plant has flowered regularly for many years in a cold frame in the Edinburgh Botanical Garden. The root-stock is the officinal part. It has a roundish tuberous form, is black externally, white and milky within, and varies in size from that of a walnut to that of a moderate-sized turnip. It contains a resin, in which its active properties reside. It is used in the form of powder and tincture, as an active irritant cathartic. The root of *Convolvulus Scammonia* yields a gummy resinous exudation, which constitutes medicinal Scammony. The plant grows abundantly in Greece, the Grecian Islands, and various parts of the Levant. The plant succeeds well in a cold frame in the Edinburgh Botanic Garden. The Jalap and Scammony plants flower freely in the open border in the garden. Scammony is procured by cutting the root across, and collecting the milky juice which soon concretes. The drug is imported into this country from Smyrna. Its active principle is a resin. It is used medicinally as a drastic purgative, in the form of powder, pill, and extract. A spurious kind of Scammony has been prepared from the root of *Convolvulus* (*Calystegia*) *sepium;* and several plants

belonging to the natural order Asclepiadaceæ yield a purgative exudation, which has been used under the names of Montpellier and Bourbon Scammony (¶ 124). The roots of some of the plants do not possess purgative qualities, and have been used as articles of food. *Batatas edulis* (*Convolvulus Batatas*) yields the sweet Potato, which contains much saccharine and amylaceous matter, and is used as food in tropical countries. The plant is reared in Carolina, Japan, and China, and succeeds within an annual Isotherm of 59° F. It is cultivated also in Spain and Portugal. In the Philippine Islands the Batatas or Camotas, as they are called, are used for making soup, as well as roasted. The species of *Cuscuta*, Dodder, or scald-weed, have acrid purgative properties. Their seeds germinate in the soil, and the plants afterwards twine round others, and become attached to them by means of suckers. They then lose their connection with the soil, and are supported as true parasites. In this way they often destroy crops of Flax and Clover, Beans and Hops. *Calonyction speciosum* is a night-flowering plant, with large white blossoms, and has received the name of Moon-plant. *Convolvulus scoparius* yields a perfume called Rhodium. *Ipomæa bona-nox* is the moon-flower of Ceylon and of other warm countries.

957. Order 132.—**Cordiaceæ**, the Cordia Family. (*Monopet. Hypog.*) Calyx 4-5-toothed, inferior. Corolla monopetalous, 4-5-cleft, regular. Stamens inserted on the corolla, alternate with its segments; anthers versatile. Ovary free, 4-8-celled; ovules solitary, pendulous, anatropal; style continuous; stigma 4-8-cleft. Fruit drupaceous, 4-8-celled. Seed exalbuminous, pendulous from the apex of the cell by a long funiculus, upon which it is turned back; radicle superior; cotyledons plaited longitudinally.—Trees, with alternate, rough, exstipulate leaves, and panicled flowers. They are chiefly natives of warm countries. Some yield edible fruits; their bark is occasionally bitter, tonic, and astringent, and their wood is used for various economical purposes. The succulent, mucilaginous fruits of *Cordia Myxa* and *latifolia*, receive the name of Sebesten Plums. There are 11 genera enumerated by Lindley, including 188 species. *Examples*—Cordia, Varronia.

958. Order 133.—**Boraginaceæ**, the Borage Family. (*Monopet. Hypog.*) Calyx persistent, with 4-5-divisions (figs. 660, 661 *c*). Corolla gamopetalous, hypogynous, usually regular (figs. 296, 297), 5- rarely 4-cleft; æstivation imbricated (figs. 660, 661 *p p*). Stamens inserted on the corolla, equal in number to its segments, and alternate with them (fig. 661 *e*). Ovary usually 4-lobed, quadrilocular (fig. 661 *o*); ovules 4, each attached to the lowest point of the cavity, amphitropal; style simple, basilar (figs. 403, 661 *s*), (terminal in Ehretieæ and Heliotropieæ); stigma simple or bifid. Fruit (fig. 662) consisting of 2 to 4 distinct achænia (succulent and consolidated in Ehretieæ). Seed

exalbuminous, or with thin albumen; radicle superior; cotyledons plano-convex (fig. 662).—Herbs, shrubs, or trees, with terete stems,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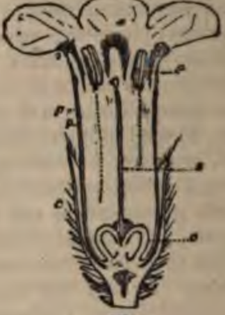

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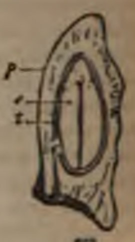

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alternate, rough, exstipulate leaves, and flowers generally in scorpioidal (gyrate) cymes (fig. 253). On account of the asperities in the leaves, the plants have sometimes been called Asperifoliæ. The order is divided into three suborders:—1. Boragineæ (figs. 660-662), with a basilar style, 4-lobed ovary, achænium-like fruit, and exalbuminous seeds; natives chiefly of temperate climates. 2. Ehretieæ, with a terminal style, a quadrilocular, concrete ovary, a succulent fruit, and usually albuminous seeds; natives of tropical countries. 3. Heliotropieæ, with a terminal style, an entire or 2-lobed ovary, a dry fruit separable into four achænia, and exalbuminous seeds; natives partly of temperate, and partly of warm climates. There are 75 known genera, and nearly 950 species. *Examples*—Borago, Anchusa, Echium, Myosotis, Cynoglossum, Ehretia, Heliotropium.

959. The plants of the order are generally mucilaginous and emollient. Some are astringent. Nitrate of potash exists in some, and imparts coolness to the water in which they are steeped. *Borago officinalis*, Borage, has been used for its mucilaginous emollient properties, as a remedy in pectoral affections; and with wine, water, lemon, and sugar, its leaves form an ingredient in what is called cool-tankard. Attached to the stamens in this plant, and others of the order, are scales, which may be considered as abortive stamens, formed by dilamination

Figs. 660-662.—Organs of fructification of Anchusa italica, to illustrate the natural order Boraginaceæ.

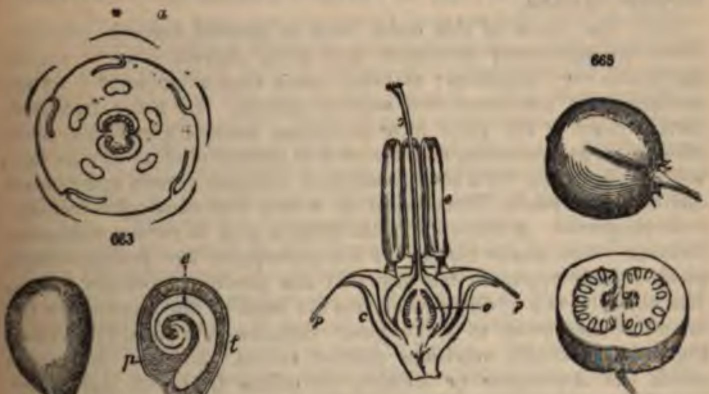
Fig. 660.—Diagram of the flower, with five imbricated divisions of the calyx, five imbricated segments of the corolla, five stamens, and a 4-lobed ovary.

Fig. 661.—Vertical section of the flower. *c*, Hairy calyx. *p p*, Corolla. *s*, Stamens inserted into the corolla. *a a*, Staminal appendages or corolline scales. *o*, 4-lobed ovary, two of its divisions cut through vertically. *s*, Basilar style.

Fig. 662.—One of the carpels (achænia) cut vertically. *p*, Pericarp separable from the seed. *t*, Spermoderm or integuments of the seed. *e*, Embryo with superior radicle, and plano-convex cotyledons.

(fig. 312). *Anchusa tinctoria* supplies alkanet root, which is used as a reddish-brown dye. Some of the species of *Heliotropium* (as *H. peruvianum*) are distinguished by their fragrant odour. The leaves of *Mertensia* (*Lithospermum*) *maritima* have the taste of oysters, and hence it is called the Oyster-plant in Scotland. *Myosotis palustris* (fig. 279) is the true Forget-me-not. Miss Strickland remarks, that the banished and aspiring Henry of Lancaster appears to have been the person who gave to this plant its emblematical and poetical meaning, by uniting it in his exile with the initial letter of his watchword, 'Souveigne-vous-de-moy.'

960. Order 134.—**Solanaceæ**, the Nightshade Family. (*Monopet. Hypog.*) Calyx inferior, 5- rarely 4-partite, persistent (fig. 664 *c*). Corolla monopetalous, hypogynous, with the limb 5- rarely 4-cleft, regular, or somewhat unequal, deciduous; æstivation plicate or imbricated (fig. 663). Stamens inserted on the corolla (fig. 664 *e*), equal in number to the corolline segments, and alternate with them (fig. 663); anthers with longitudinal or porous dehiscence (fig. 664 *e*). Ovary usually 2-celled (fig. 664 *o*), sometimes 4-5- or many celled; ovules indefinite; style continuous; stigma simple (fig. 664 *s*). Fruit with 2, 4, or more cells, rarely unilocular; either a capsule dehiscing in a



Figs. 663-668.—Organs of fructification of Solanum tuberosum, the Potato, to illustrate the natural order Solanaceæ.

Fig. 663.—Diagram of the flower, with five divisions of the calyx, five plicate segments of the corolla, five stamens, and a 2-celled ovary with polyspermous placentas. *a*, Axis.

Fig. 664.—Vertical section of the flower. *c*, Calyx. *p p*, Lower part of the corolla. *e*, Stamens, with porous dehiscence of the anthers. *o*, Bilocular ovary, polyspermous. *s*, Style and stigma.

Fig. 665.—Fruit, baccate.

Fig. 666.—Horizontal section of the fruit, showing the seeds and placenta.

Fig. 667.—The seed.

Fig. 668.—Vertical section of the seed. *t*, Integument (spermoderm) of the seed. *p*, Fleshy perisperm (albumen). *e*, Embryo, which is curved and excentric, with the radicle next the hilum.

septicidal or circumscissile manner, and having a double dissepiment parallel to the valves, or a berry (figs. 665, 666) with the placentas adhering to the dissepiment, or a nuculanium with 5 or more nucules. Seeds 00; embryo straight or curved (fig. 668), often excentric, lying in fleshy albumen; radicle next the hilum.—Herbs or shrubs, with alternate leaves. Natives of most parts of the world, but abundant in the tropics, in which the mass of the order exists, in the form of the genera Solanum and Physalis. The order has been divided into two sections, which are not, however, well defined:—1. Rectembryæ, with the embryo nearly straight. 2. Curvembryæ, with the embryo curved in a semicircular, annular, or spiral manner. These are subdivided into tribes, chiefly according to the nature of the fruit. There are 79 known genera, and 1025 species enumerated; but there is considerable difficulty in the allocation of the genera. *Examples*—Cestrum, Habrothamnus, Nicotiana, Petunia, Datura, Hyoscyamus, Solanum, Physalis, Nolana.

961. The plants of this order have in general narcotic qualities. These are sometimes developed in a great degree, so as to render the plants very poisonous; at other times they are obscured by the prevalence of nutritious and starchy matter. In many instances, certain parts of the plant have poisonous narcotic properties, while other parts are harmless, and are used as articles of diet. These facts will be illustrated by a consideration of different genera and species. *Solanum Dulcamara*, Bitter-sweet or woody Nightshade, has diaphoretic properties. A decoction of the twigs is used in various cutaneous diseases. The scarlet berries are not poisonous; five pounds weight given in the course of ten days did not produce poisonous effects. The black berries of *Solanum nigrum* are used by the garrison in the Island of Ascension to make pies. *Solanum tuberosum*, the Potato (fig. 92), produces nutritious starchy tubers. *Solanum Melongena* yields the Aubergine or Brinjal, an edible fruit. *S. laciniatum*, the Kangaroo apple, is eaten in Tasmania. In the genus *Solanum* the anthers open by pores. *Atropa Belladonna*, Deadly Nightshade or Dwale, is a highly poisonous plant belonging to this order. All parts of the plant are narcotic. The fruit is a dark brownish-black shining berry, which often proves attractive to children. The leaves are the part used in medicine, and from these an extract is prepared. The watery extract is best made in vacuo, but the alcoholic extract is probably the best. Belladonna is one of our most active indigenous poisons. It owes its properties to the presence of an alkaloid called Atropia, which exists in the plant in combination with malic acid. Belladonna is used medicinally to allay pain and spasmodic action, to cause dilatation of the pupil, and as a prophylactic against scarlatina. Similar properties exist in the species of *Hyoscyamus*, more especially in *H. niger*, Henbane, a biennial plant

with dingy-yellow flowers, exhibiting beautiful purple reticulations, hairy viscous leaves, and a bilocular operculate capsule (fig. 459). The leaves yield by expression a large quantity of juice, whence an extract is prepared. A tincture of Henbane is often used in place of laudanum, on account of not causing constipation. It is employed in medicine to procure sleep and allay pain, and it acts also in dilating the pupil. The narcotic properties seem to be owing to an easily decomposed alkaloid called Hyoscyamia. An empyreumatic oil is obtained from the plant, which is an energetic narcotic poison. The roots of the plant have sometimes caused poisoning by being mistaken for parsnips. Many species of *Datura* are powerfully narcotic. *D. Stramonium* is the Thorn-apple, so called on account of its prickly capsule. Its leaves and seeds are used medicinally as narcotics, their qualities being due to an alkaloid called Daturia. They are prescribed as anodynes and antispasmodics, in the form of powder, extract, and tincture, and the leaves are smoked in cases of asthma. *Datura Tatula* and *Metel*, *sanguinea*, *ferox* and *fastuosa* have similar properties. Several species of *Nicotiana* furnish Tobacco. That chiefly used in Europe is procured from *N. Tabacum*, a plant naturally inhabiting the hotter parts of North and South America. It is an annual plant, attaining a height of six feet, having dingy-red infundibuliform flowers (fig. 294) and viscid leaves. The leaves are the officinal part, and their active properties depend on a peculiar oily-like alkaloid called Nicotina. They are employed in the form of infusion, tincture, and wine. Tobacco is an energetic narcotic poison. Its oil, which is inhaled and swallowed in the process of smoking, is one of the most deadly known poisons. The Hottentots are said to kill snakes by putting a drop of it on their tongues: the death of these reptiles is said to take place instantaneously. It is employed medicinally as a sedative, and its depressing action is useful in cases of hernia. Its depressing action is indicated by its effect on the cerebral functions and on the heart. The flavour and strength of tobacco depend on climate, cultivation, and the mode of manufacture. That most esteemed by the smoker is Havannah tobacco; but the Virginian is the strongest. It is said that small Havannah cigars are prepared from the leaves of *Nicotiana repanda;* Syrian and Turkish tobacco from *N. rustica*, and fine Shiraz tobacco from *N. persica*. The fruit of different species and varieties of *Capsicum* supply Cayenne-pepper, and what are called Chillies. Chilli is the Mexican name for all the varieties of Capsicum. They are natives of the East and West Indies, and of other hot climates. *Capsicum annuum* is the species commonly noticed, but of it there seems to be numerous varieties, which by many are reckoned species. Thus, *C. frutescens* is a shrubby plant which, along with *C. minimum*, supplies the variety called Bird-pepper; *C. baccatum* has a globular fruit, and furnishes Cherry or Berry-capsicum. In Capsicum irritant properties prevail, without any narcotic action. Their acridity is owing to an oleaginous substance called Capsicin. Cayenne-pepper is used chiefly in the form of tincture as a rubefacient and stimulant, especially in cases of ulcerated sore throat. It acts on the stomach as an aromatic condiment, and, when preserved in acetic acid, it forms Chilli vinegar. *Mandragora officinalis* (*Atropa Mandragora*), Mandrake, acts as a stimulant on the nervous system, and its forked root was long celebrated for its properties in this respect. It is the דודאים, (Dudaim) of the Bible. Its root is easily made to assume the human form, and hence has arisen the stories of the plant shrieking when torn out of the ground. By the Arabs the plant is called Tufah-al-Sheitan, or Devil's apple. The species of *Physalis* are remarkable for their accrescent calyx (fig. 280). The fruit of some, such as *P. peruviana*, Peruvian Winter Cherry, is eaten. The fruit of *Lycopersicum esculentum* is the edible Tomato, or Love-apple; that of *Solanum ovigerum* is the Egg-apple.

A division of the genera of this order has been made by M. Fee into—1. Those which contain species, all of which are more or less poisonous, as *Datura*, *Hyoscyamus*, *Atropa*, *Nicotiana*, &c. 2. Those which contain some species doubtfully poisonous, and others innocuous or stimulant, as *Solanum* and *Capsicum*. 3. Those having species which are all innocuous, as *Lycopersicum*. Miers has revised the genera included in the orders Solanaceæ and Scrophulariaceæ, and he proposes to institute an intermediate order, Atropaceæ, as follows:—

1. Solanaceæ; Isomerous flowers with a valvate or induplicato-valvate æstivation; inflorescence extra-axillary.

2. Atropaceæ; Isomerous flowers or nearly so, with a more or less imbricate æstivation; inflorescence extra-axillary, narcotic; cause dilatation of the pupil.

3. Scrophulariaceæ; Anisomerous flowers with imbricate æstivation: organs of inflorescence truly axillary.

962. Order 135.—**Orobanchaceæ**, the Broom-rape Family. (*Monopet. Hypog.*) Calyx divided, persistent, inferior. Corolla monopetalous, hypogynous, irregular, usually bilabiate, persistent; æstivation imbricated. Stamens 4, didynamous. Disk fleshy. Ovary free, 1-celled, composed of two carpels which stand fore and aft, with 2 or more parietal placentas; ovules 00; style 1; stigma 2-lobed, each of the lobes belong half to each carpel. Fruit capsular, enclosed within the withered corolla, 1-celled, 2-valved. Seeds 00, minute; embryo very minute, at one end of fleshy albumen.—Herbaceous parasitical plants, having scales in place of leaves. They are natives of Europe, more especially the southern parts, and of Asia, North America, and the Cape of Good Hope. Authors give 14 genera, and 127 species. *Examples*—Orobanche, Lathræa.

963. The properties of the plants of the order are, in general, astrin-

gency and bitterness. Some have been used as tonics, and as applications to indolent ulcers. The species of *Orobanche* are called Broom-rapes, on account of the ravages they are supposed to commit on the Broom tribe. They attach themselves to the roots of various plants, and are hence called Root-parasites. Different species infest and injure different tribes of plants. Thus, *Orobanche Rapum* is parasitical upon Broom and Furze; *O. ramosa*, upon Hemp; *O. rubra*, upon common Thyme; *O. minor*, upon red Clover; *O. Hederæ*, upon the Ivy; *O. elatior* and *arenaria*, upon different species of Compositæ, as Centaury and Milfoil. The stems of Orobanches have a large central cellular portion, surrounded by numerous fibro-vascular bundles, which are arranged in a circle without any medullary rays. Tubers exist at the lower part, whence subterranean buds are developed. Sometimes the fibro-vascular bundles of the plants, to which the Broom-rapes are attached, are found ramifying in the substance of the parasite. As Broom-rapes possess tubers and ordinary roots, Henfrey is disposed to think that they also derive nourishment from the soil in the usual way. *Lathræa squamaria*, Tooth-wort, is parasitical upon the roots of Hazels, Cherry-laurels, and other trees. *Epiphegus virginiana*, Beech-drops, has been used in powder as an application to cancerous sores. In conjunction with white oxide of Arsenic, it is supposed to have constituted the specific known in North America under the name of Martin's Cancer Powder.

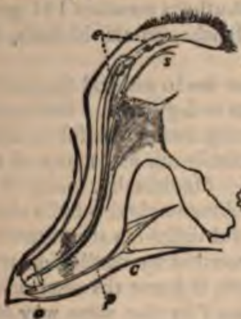
964. Order 136.—**Scrophulariaceæ**, the Figwort Family. (*Monopet. Hypog.*) Calyx divided into 4 or 5 parts, unequal, persistent, inferior (fig. 288 *c*). Corolla monopetalous, more or less irregular and bilabiate (fig. 288 *p*), or personate (fig. 300), sometimes spurred or saccate at the base; æstivation imbricate. In the bud, the flowers are regular (fig. 305). Stamens usually 4, didynamous (figs. 344, 346), rarely 5, sometimes 2; anthers bilocular, or unilocular by abortion or adhesion. Ovary free, 2-celled; ovules usually 00; style simple; stigma 2-lobed, rarely entire. Fruit capsular, rarely fleshy, dicarpellary, 2-celled (fig. 445), 2-4-valved, opening by septicidal or loculicidal dehiscence, rarely by pores (fig. 462) or lids, the dissepiments becoming finally loose in the centre (fig. 446). Placentas attached to the dissepiment, and sometimes in the mature fruit becoming central. Seeds definite or 00; embryo straight or slightly curved, included within fleshy albumen.—Herbs, undershrubs, or shrubs, with opposite, whorled or alternate leaves. They are found generally distributed over the globe, both in cold and warm regions. The order has been divided by Bentham into three sections:—1. Salpiglossideæ. 2. Antirrhinideæ. 3. Rhinanthideæ. The characters of these divisions are founded on the nature of the inflorescence, whether centrifugal, centripetal, or compound, and the æstivation of the corolla. There are 183 known genera, and 1947 species. *Examples*—Schizanthus, Salpiglossis, Cal-

ceolaria, Verbascum, Antirrhinum, Scrophularia, Pentstemon, Mimulus, Digitalis, Veronica, Rhinanthus, Melampyrum.

965. The plants of the order are usually scentless, or at all events not aromatic. They are acrid and slightly bitter, and some of them are sedative and poisonous. Some of the plants of the order belong to the tribe of Root-parasites. This is particularly the case with species of *Euphrasia*, *Rhinanthus*, *Bartsia*, *Melampyrum*, and *Pedicularis*. These parasites differ from Broom-rapes in having green leaves, and they seem to be apparently independent after they have acquired a certain degree of development. The species of *Mimulus* have a bilamellate stigma, the two lamellæ of which are irritable, and close when irritated. The movements of the stigma are probably in some way connected with fertilization. One of the species, ***Mimulus luteus***, has become naturalized in many parts of Britain, as in the neighbourhood of Edinburgh, on the shores of the Clyde, the Isle of Skye, Perthshire, &c. ***Mimulus moschatus*** is cultivated on account of its musk-like odour. The most important medicinal plant of the order is ***Digitalis purpurea***, Foxglove, the leaves and seeds of which are employed in the form of powder, tincture, and infusion. The leaves have a bitter taste, which they retain when carefully dried. In large doses they act as a narcotico-irritant poison, and in small doses they are used as sedative of the circulation, and diuretic. Their continued use causes great slowness of the pulse, and hence their employment in diseases of the heart and in hæmorrhages, such as hæmoptysis. In dropsical cases, especially those connected with diseased heart, Digitalis is extensively used. Its active properties are due to the presence of a crystalline principle called Digitalin. Several other species of Digitalis, such as *D. lævigata*, *grandiflora*, *lutea*, and *tomentosa*, have similar properties. The leaves of ***Scrophularia nodosa***, knotted Figwort, have irritant qualities, and have been used as emetic and cathartic remedies. In the form of ointment and fomentation, they have been applied to diseases of the skin and tumours. The woolly leaves of *Verbascum Thapsus*, Great Mullein, are emollient and slightly narcotic. They have been used in some pectoral affections. The species of *Melampyrum* are called Cow-wheat, in consequence of being relished by cows. *Euphrasia officinalis*, Eye-bright, or Euphrasy, was formerly used in cases of ophthalmia. Some of the species of *Linaria* and *Calceolaria* are used for dyeing. ***Linaria vulgaris*** exhibits what Linnæus called Peloria (¶ 654, 655), by the flowers being 5-spurred in place of 1-spurred, and thus becoming symmetrical. *Gratiola officinalis*, Hedge-hyssop, is bitter and acrid, and is said to enter into the composition
au médicinale, so much vaunted as a remedy for gout. This
erly called Gratia Dei, on account of its efficiency as a medi-
over doses it acts as a poison. According to Haller, it renders
undance some of the Swiss meadows useless as pastures. The

leaves of *Veronica officinalis* are bitter and astringent, and are sometimes used as tea.

966. Order 137.—**Labiatæ** (Lamiaceæ of Lindley), the Labiate Family. (*Monopet. Hypog.*) Calyx tubular, inferior, regular or bilabiate, persistent (fig. 670, 672 *c*). Corolla monopetalous, hypogynous, bilabiate; upper lip entire or bifid, lower 3-lobed (figs. 299, 670, 671). Stamens 4 (fig. 669), didynamous (fig. 671 *e*), sometimes 2 by abortion, inserted into the corolla, and alternate with the lobes of the lower lip; anthers 2-celled, or 1-celled by abortion, or by absorption of the septum (fig. 333); connective sometimes large and distractile (fig. 333 *c*). Disk fleshy. Ovary free, deeply 4-lobed



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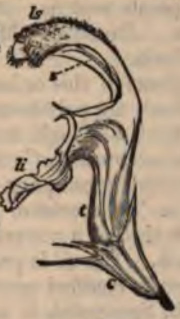

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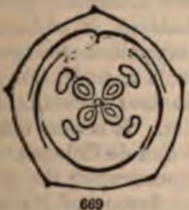

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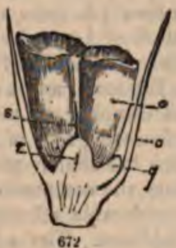

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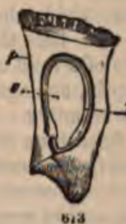

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Figs. 669-673.—Organs of fructification of Lamium album, to illustrate the natural order Labiatæ.

Fig. 669.—Diagram of the flower, with the pentamerous calyx; pentamerous corolla, having two lips, the upper lip being formed of two united petals, the lower of three; four stamens, in consequence of one being undeveloped, and four divisions of the ovary.

Fig. 670.—Entire flower viewed laterally. *c*, Five-cleft calyx. *t*, Tube of the corolla. *l s*, Upper lip of two petals. *l i*, Lower lip of three. *s*, Style.

Fig. 671.—The flower cut vertically. *c*, Calyx. *p*, Corolla. *e*, Didynamous stamens. *s*, Style and bifid stigma. *o*, Ovary.

Fig. 672.—Fruit (a tetrachænium) cut vertically, showing the carpels, two of which have been removed. *c*, Persistent calyx. *g*, Fleshy disk or gland. *r*, Gynobasic receptacle bearing the style, *s*, which is basilar, *i. e.* arises from the lower part of the carpels. *o*, Two carpels, which form achænia when ripe.

Fig. 673.—A carpel cut vertically. *p*, Pericarp. *t*, Integument of the seed. *e*, Embryo erect with inferior radicle.

(figs. 402, 669); ovules 4; style 1, basilar (figs. 402, 671 *s*); stigma bifid (fig. 671 *s*), usually acute. Fruit consisting of 1-4 achænia, enclosed within the persistent calyx (figs. 402, 672). Seeds erect (fig. 673); albumen either 0, or in small quantity; embryo erect (fig. 673 *e*); cotyledons flat; radicle inferior.—Herbs or undershrubs, with tetragonal stems, opposite exstipulate leaves, and cymose inflorescence, the flowers being often in verticillasters. Linnæus looked upon the fruit as naked seeds, and hence included many of the plants in the order Gymnospermia of his Didynamous class. They are natives chiefly of temperate regions. Authors mention 131 genera, including 2470 species. *Examples*—Mentha, Salvia, Melissa, Lamium, Teucrium, Scutellaria.

967. The plants of this order are in general fragrant and aromatic, and none of them are poisonous or injurious. Scarcely any are used for ordinary food, although many form grateful condiments. Their leaves contain receptacles of volatile oil, and many of them furnish a stearoptin resembling camphor. Medicinally, many of them are used as carminatives. The species of *Mentha* yield volatile oils. *M. Piperita*, Peppermint, is used as a powerful diffusible stimulant in cases of colic and gastrodynia. The oil is procured by distillation with water, and, when dissolved in rectified spirit, it forms ths essence of Peppermint. *Mentha viridis*, Spearmint, is used in the same way as Peppermint; while *M. Pulegium*, Penny-royal, is employed as a pectoral and antispasmodic. *Lavandula vera* (*L. spica*, *officinalis*, and *angustifolia* of authors) yields the best oil of Lavender; while *L. latifolia* furnishes Spike-oil. Like the other volatile oils of the Labiatæ, oil of Lavender consists of a fluid oil, or Elæoptin, and a solid crystalline substance, or Stearoptin, analogous to camphor. Lavender is a tonic, stimulant, and carminative. The flowering tops of *Rosmarinus officinalis*, Rosemary, furnish an oil which has similar properties. It is used much in perfumery, and enters into the composition of Eau de Cologne. It is reputed as possessing considerable efficacy in encouraging the growth of hair and in curing baldness. The admired flavour of Narbonne honey is ascribed to the bees feeding on the flowers of this plant. Oils of the same nature are procured from *Origanum vulgare*, Wild Marjoram, *O. Majorana*, Sweet Marjoram, *Melissa officinalis*, common Balm, and *Marrubium vulgare*, white Horehound. Some consider the Hyssop of Scripture, אזוב, as being *Hyssopus orientalis* (*H. officinalis*, var. *angustifolius*); but Royle looks upon it as one of the Caper plants (*Capparis ægyptiaca*). *Plectranthus graveolens* of some, *Pogostemon suavis* or *P. Patchouly* of others, is the Patchouli plant of the East ies, which is used as a perfume. It is called in India puchá pát. lds a volatile oil of a yellowish-green colour. *Lycopus virginicus*, -weed, and *L. europæus*, Gipsey-wort, are used as astringents datives. Many Labiates, such as Thyme (*Thymus*), Mint (*Men-*

tha), Sage (*Salvia*), Basil (*Ocymum*) Savoury (*Satureia*), &c., are used as culinary vegetables, more particularly to flavour sauces and dishes. The species of *Salvia* are distinguished by having only two stamens in consequence of the abortion of the rest, and by their distractile connective, which separates the anther lobes (fig. 333). In the episperm of the seeds of the species of Salvia there are beautiful spiral cells, the fibres of which, like those of Collomia, uncoil when moistened with water, and form an interesting microscopic object. *Salvia officinalis*, common sage, has been used in the form of tea as a stomachic. What are called Sage-apples, are galls produced by the puncture of insects on *Salvia pomifera*. The roots of *Ocymum tuberosum* are said to be esculent. *Hyptis membranacea*, one of the Brazilian Labiates, attains the height of twenty or thirty feet.

968. Order 138.—**Verbenaceæ,** the Vervain Family. (*Monopet. Hypog.*) Calyx tubular, persistent, inferior. Corolla monopetalous, tubular, hypogynous, deciduous, limb usually irregular; æstivation imbricated. Stamens usually 4, didynamous, rarely equal, sometimes 2. Ovary free, 2-4-celled; ovules usually 4, erect or pendulous, anatropal or amphitropal; style 1, terminal; stigma bifid or entire. Fruit nucamentaceous or baccate, composed of 2 or 4 achænia united. Seeds 1-4; albumen 0 or fleshy; embryo straight; radicle either inferior or superior.—Trees or shrubs, rarely herbs, with opposite or alternate, exstipulate leaves. The order has been divided into three suborders:—1. Myoporineæ, anthers 2-celled, seed pendulous, radicle superior; natives of the southern parts of America and Africa, and of Australia. 2. Verbeneæ (fig. 237), anthers 2-celled, seed erect, radicle inferior; natives both of the tropical and temperate regions of America, and found also in Asia and in Europe. 3. Selagineæ, anthers 1-celled, seed pendulous, radicle superior; natives chiefly of the Cape of Good Hope, but some are European. There are 75 known genera, and upwards of 850 species. *Examples*—Myoporum, Avicennia, Verbena, Vitex, Tectona, Selago, Globularia.

969. Many of the plants of the order are fragrant and aromatic, some are bitter, tonic, and astringent, others are acrid. None of them occur in the British Pharmacopœias. *Aloysia citriodora*, Sweet-scented Verbena, is commonly cultivated for its fragrance. In the leaves, Dr. Murchison has noticed peculiar glands containing oily matter. The species of *Avicennia* have adventitious roots like the Mangrove. The bark of *Avicennia tomentosa* is used in Brazil for tanning. *Tectona grandis* is the Teak-tree of India, the wood of which is very hard and durable, and is used for ship-building. A fine specimen exists in the Edinburgh Botanic Garden. The trunk of the tree in Eastern forests sometimes attains a height of two hundred feet, and its leaves are twenty inches long by sixteen broad. *Clerodendron* leaves when bruised are employed to kill vermin on cattle in India. The twigs form tooth-

picks. *Myoporum platycarpum* of Australia exudes a saccharine matter from its stem. The fruit of several species of *Vitex* is acrid and aromatic. Some species of *Lantana* and *Stachytarpheta* are used for tea. The Vervain was a sacred plant among the Greeks, and it was looked upon by the Druids with superstitious reverence.

970. Order 139.—**Acanthaceæ**, the Acanthus Family. (*Monopet. Hypog.*) Calyx with 4-5 divisions, equal or unequal, occasionally multifid, or entire and obsolete, persistent. Corolla monopetalous, hypogynous, usually irregular, with the limb ringent or bilabiate, or rarely unilabiate, sometimes nearly equal, deciduous. Stamens inserted on the corolla, usually 2, sometimes 4, didynamous, the shorter ones being occasionally sterile; anthers 1-2-celled, with longitudinal dehiscence. Disk glandular. Ovary free, 2-celled; placentas adhering to the axis; ovules 2 or more in each cell, curved; style 1; stigma 2-lobed, rarely entire. Fruit a 2-celled capsule, dehiscing by 2 elastic valves, in a loculicidal manner. Seeds 2 or many in each cell, sometimes solitary, roundish, attached to hard, persistent, hooked or subulate ascending processes of the placenta; testa loose; albumen 0; embryo curved or straight; cotyledons large, leafy; radicle cylindrical, next the hilum.—Herbaceous plants or shrubs, with opposite, exstipulate, simple leaves, and bracteated flowers; 2 or 3 large leafy bracts accompanying each flower. They abound in tropical regions. The order has been divided into three tribes:—1. Thunbergieæ, with the placental processes in the form of a hard cup, supporting the seed. 2. Nelsonieæ, with the placental processes contracted into a papilla, bearing the seed, which is small and pitted. 3. Echmatacanthi, with the placental processes hooked. There are 168 genera, according to authors, and about 1500 species. *Examples*—Thunbergia, Nelsonia, Acanthus, Justicia, Ruellia.

971. The plants of the order have mucilaginous and bitter properties in general, but they are not put to important uses. The leaves of *Acanthus*, with their sinuated lobes, gave origin to the capital of the Corinthian pillar. *Acanthus mollis* has emollient qualities. The seeds of *Acanthodium spicatum* have beautiful spiral cells in their episperm (¶ 11). The style of *Ruellia* (*Goldfussia*) *anisophylla* exhibits a peculiar irritability; its curved stigmatic apex becoming gradually straightened so as to come into contact with the hairs of the corolla upon which the pollen is scattered. A deep-blue dye, called Room, is obtained in Assam from a species of Ruellia. A similar dye in China is procured from a species of *Justicia*. Many of the species of *Justicia*, *Ruellia*, and *Aphelandra*, are cultivated for their showy flowers.

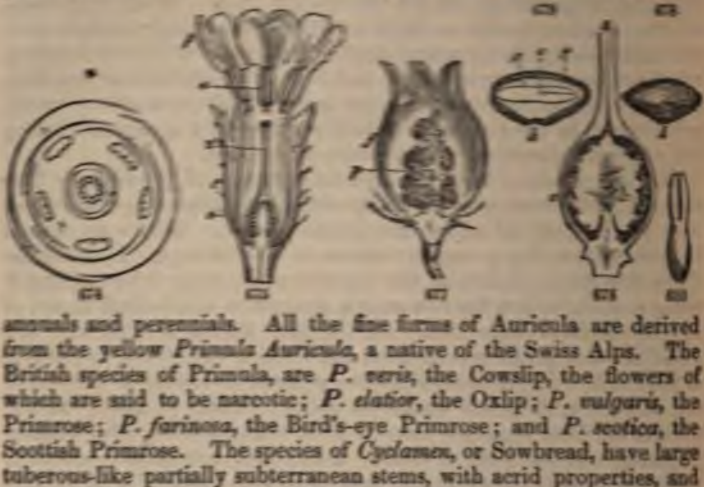
Order 140.—**Lentibulariaceæ**, the Butterwort Family. (*Mono-*
g.) Calyx inferior, divided, persistent. Corolla monopeta-
ogynous, irregular, bilabiate, usually spurred. Stamens 2,
nto the base of the corolla, and included; anthers monothecal,

sometimes contracted in the middle. Ovary free, composed of 2 carpellary leaves, unilocular; ovules 00, anatropal; placenta free, central; style 1, very short; stigma bilamellar. Fruit a 1-celled capsule, dehiscing transversely, or by an apicilar cleft. Seeds numerous, minute, exalbuminous; embryo sometimes undivided; radicle next the hilum.—Aquatic or marsh herbaceous plants, with radical leaves, which are sometimes compound, and bear little bladders or ampullæ. Flowers often on scapes. They are found in all parts of the world, and abound in the tropics. Lindley enumerates 4 genera, including 181 species. *Examples*—Utricularia, Pinguicula.

973. The plants of the order have no properties of importance. The name of Butterwort, given to the species of *Pinguicula*, may be derived from the property of giving consistence to milk. Others say that it has reference to the greasy appearance of their foliage. Linnæus declares that the solid milk of the Laplanders is prepared by pouring it warm and fresh from the cow over a strainer on which fresh leaves of Pinguicula have been laid. Of the four British species, one (*P. grandiflora*) is peculiar to Ireland, and another (*P. alpina*) is peculiar to Scotland. *Utricularias*, Bladderworts, are so called on account of the utricles or bladders connected with the leaves (¶ 164). In the interior of these vesicles a mucous fluid is found along with cellular projections in the form of hairs. *Utricularia nelumbifolia* grows in the water which collects in the bottom of the leaves of a large Tillandsia in Brazil. It sends out runners and shoots, and often in this way unites several plants of Tillandsia. The leaves are peltate, and more than three inches across, while the flowering stem is two feet long.

974. Order 141.—**Primulaceæ**, the Primrose Family. (*Monopet. Hypog.*) Calyx 5- rarely 4-cleft (fig. 272), inferior or half superior, regular, persistent (figs. 675 *c*, 677). Corolla monopetalous (fig. 295 *p*), hypogynous (fig. 675), rarely perigynous, with the limb 5- rarely 4-cleft, sometimes 0 (fig. 543). Stamens inserted on the corolla, equal in number and opposite to its segments (figs. 674, 675). Ovary free, (figs. 675, 676 *o*), rarely adherent to the base of the calyx, 1-celled; ovules 00, usually amphitropal; style 1 (fig. 675 *s*); stigma capitate (fig. 675). Fruit a capsule, opening with valves (fig. 677), or with a lid (fig. 458). Seeds numerous, peltate (fig. 678), attached to a free central placenta (fig. 677); embryo straight (fig. 680), enclosed within fleshy albumen, and lying across the hilum (fig. 679).—Herbaceous plants, with leaves usually opposite, and frequently radical, exstipulate; flowers on simple or umbellate scapes. They are natives chiefly of temperate and cold regions in the northern hemisphere; some occur in elevated situations in warm countries. Authors notice 32 genera, including 242 species. *Examples*—Primula, Androsace, Glaux, Trientalis, Anagallis, Samolus.

975. None of the plants of this order occur in the British Pharmacopœia, and few of them have any important medicinal properties. Acridity prevails more or less in the order. They are cultivated as showy garden annuals and perennials. All the fine forms of Auricula are derived from the yellow *Primula Auricula*, a native of the Swiss Alps. The British species of Primula, are *P. veris*, the Cowslip, the flowers of which are said to be narcotic; *P. elatior*, the Oxlip; *P. vulgaris*, the Primrose; *P. farinosa*, the Bird's-eye Primrose; and *P. scotica*, the Scottish Primrose. The species of *Cyclamen*, or Sowbread, have large tuberous-like partially subterranean stems, with acrid properties, and their English name is derived from the circumstance of their being eaten as food by wild boars. In them, as well as in the species of *Dodecatheon*, the petals are reflexed. The flowers of the species of *Anagallis* are meteoric (¶ 484), and their seed-vessel is a pyxidium (fig. 458). They are said to be acrid, and to cause inflammation of the mucous membrane. *Trientalis europæa* is the only British plant belonging to the Linnæan class Heptandria. It is slightly acrid. In *Samolus Valerandi*, Brook-weed, the calyx is partially adherent to the ovary, and in *Glaux maritima* the corolla is abortive, and the calyx becomes coloured (fig. 543).



976. Order 142.—**Plumbaginaceæ**, the Sea-pink Family. (*Monopet. Hypog.*) Calyx tubular, persistent, sometimes coloured; æstivation plaited. Corolla monopetalous, or pentapetalous, regular. Stamens 5,

Figs. 674-680.—Organs of fructification of Primula elatior, illustrating the natural order Primulaceæ.

Fig. 674.—Diagram of the flower, with five imbricate divisions of the calyx, five segments of the corolla, five stamens opposite the corolline segments, and five carpellary leaves, surrounding a free central placenta.

Fig. 675.—Vertical section of the flower. *c*, Inferior calyx. *p*, Monopetalous corolla. *e*, Stamens attached to the corolla. *o*, Superior ovary. *s*, Style with capitate stigma.

Fig. 676.—Ovary cut vertically, to show the free central placenta covered with ovules. *s*, Base of the style.

Fig. 677.—Vertical section of the fruit. *f*, Pericarp. *p*, Placenta with numerous seeds, some of which have been detached.

Fig. 678.—Peltate amphitropal seed separated. *h*, Hilum.

Fig. 679.—Seed cut vertically. *t*, Integuments (spermoderm). *h*, Hilum. *p*, Fleshy perisperm (albumen). *e*, Transverse embryo lying across the hilum.

Fig. 680.—Embryo with cotyledons and radicle.

hypogynous when the corolla is gamopetalous, attached to the base of the petals when they are separate. Ovary free, 1-celled; ovule solitary, pendulous from a funiculus which arises from the bottom of the cell; styles 5, seldom 3 or 4, each bearing a subulate stigma. Fruit a utricle. Seed pendulous; spermoderm simple; embryo straight, in the axis of mealy albumen; radicle superior.—Herbs or undershrubs, with alternate or fasciculate exstipulate leaves, somewhat sheathing at the base; flowers panicled or capitate. They inhabit the sea-shores and salt marshes chiefly in temperate regions. There are two sections of this order:—1. Plumbagineæ, with a synpetalous corolla and connate styles. 2. Staticeæ, with a pentapetalous corolla and distinct styles. Authors mention 11 genera, and 242 species. *Examples*—Plumbago, Statice, Armeria.

977. Some of the plants are acrid, others have tonic qualities. *Armeria maritima*, Thrift, or common Sea-pink, grows both on the sea-shores and on the top of the highest Scottish mountains. Its inorganic chemical ingredients are said to vary in these positions (¶ 228). In *Armeria* the funiculus curves over the foramen of the ovule in a young state, but slips off at the period of fecundation, and allows an ovular process to proceed from the exostome towards the placenta. In this genus also, the scaly bracts unite so as to form an inverted cylindrical sheath below the heads or shortened panicles of flowers. The root of *Statice caroliniana* is said to be one of the most powerful vegetable astringents. *Plumbago europæa* has been employed for the relief of toothache, and has hence been called Toothwort. Its root is so acrid that it is used in Roumelia for causing issues. Administered internally in small doses it is said to be as effectual an emetic as Ipecacuanha. Some of the species of this genus act as vesicants.

978. Order 143.—**Plantaginaceæ**, the Ribwort Family. (*Monopet. Hypog.*) Calyx 4-parted, persistent, æstivation imbricate. Corolla monopetalous, hypogynous, scarious, persistent, with a 4-parted limb. Stamens 4, inserted into the corolla, and alternate with its segments; filaments long, filiform, folded inwards in the bud; anthers dithecal, versatile. Disk inconspicuous. Ovary free, 2-4-celled; ovules solitary, or in pairs, or 00; style simple, capillary; stigma hispid, simple, rarely bifid. Fruit an operculate capsule enclosed within the persistent corolla. Seeds sessile, peltate, or erect; spermoderm mucilaginous; embryo in the axis of fleshy albumen, transverse; radicle inferior.—Herbs, which are often stemless, with radical ribbed leaves, and spiked hermaphrodite flowers, or solitary unisexual ones. The species are chiefly found in temperate and cool regions. There are 3 genera noticed by Lindley, including 129 species. *Examples*—Plantago, Littorella.

979. The plants of this order are frequently bitter and astringent.

Their mucilaginous seeds are sometimes used as demulcents. *Plantago maritima* is found both on the sea-shores, and on the top of the highest mountains in Scotland. Its inorganic constituents are said to differ in these localities (¶ 228). *Plantago major*, Way-bred, is said to follow the footsteps of man in his migrations. Its spikes are used for feeding birds. Sometimes the bractlets become large, and at other times they assume a verticillate appearance.

Subclass IV.—MONOCHLAMYDEÆ.*

980. Corolla wanting; a calyx, or what is called a simple perianth, present; flowers sometimes Achlamydeous. This subclass includes the Apetalous orders of Jussieu, and many of his Diclinous irregular orders. It corresponds to the Apetalæ and Gymnospermæ of Endlicher.

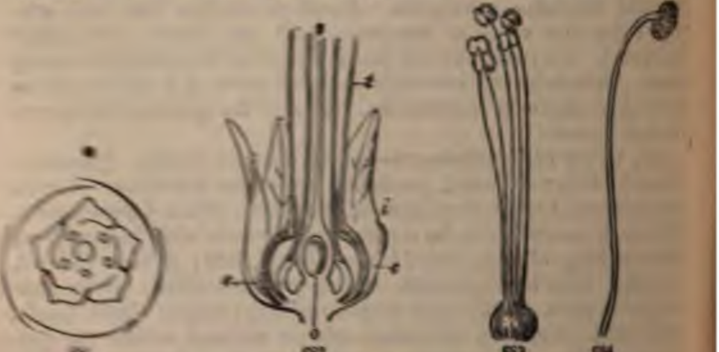
Section 1.—ANGIOSPERMÆ.†

a. SPERMOGENÆ.

Having true seeds with a Dicotyledonous embryo.

981. Monochlamydeous or Achlamydeous plants, having their seeds contained in an ovary, and fertilised by the action of the pollen on a stigma. It is the Apetalous division of Endlicher's Acramphibrya.

982. Order 144.—**Nyctaginaceæ**, the Marvel of Peru Family. (*Apet. Hypog.*) Perianth tubular, coloured, contracted in the middle, be-



Figs. 681-684.—Organs of fructification of Mirabilis Jalapa, illustrating the natural order Nyctaginaceæ.

Fig. 681.—Diagram of the flower, with an imbricated involucre, five divisions of the perianth, alternate stamens, and a unilocular ovary.

682.—Lower part of the flower cut vertically. *i*, Involucre. *c*, Base of the perianth and swollen around the ovary. *t*, Part of its coloured tube. *e*, Lower part of the filaments of the style. *o*, Ovary with its erect ovule.

683.—Stamens with convex swelling at the base of the filaments.

684.—Style and stigma.

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* Μόνος, one, and χλαμύς, a cloak or covering.

† Ἄγγος, a vessel, and σπέρμα, a seed.

coming indurated at the base (fig. 682); limb entire, or toothed and deciduous; æstivation plicate (fig. 681). Stamens definite, hypogynous (fig. 682 *e*); anthers dithecal (fig. 683). Ovary superior, 1-celled; ovule solitary, erect; style 1; stigma 1 (figs. 682, 684). Fruit a caryopsis, enclosed within the enlarged persistent tube of the perianth (figs. 441, 685, 686). Embryo peripherical (figs. 522, 686 *e*); albumen farinaceous; cotyledons foliaceous; radicle inferior (figs. 686, 687).—Herbs, shrubs, or trees, with opposite, often unequal, sometimes alternate leaves, and involucrate flowers (figs. 681, 682). They are natives principally of warm regions. Authors notice 19 genera, including 117 species. *Examples*—Mirabilis (Nyctago), Boerhaavia, Pisonia.

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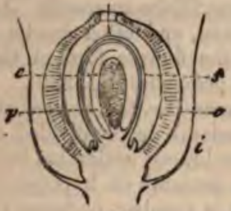

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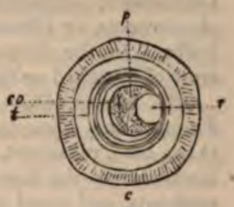

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983. The plants of the order have in general purgative qualities. *Mirabilis Jalapa* was at one time considered the Jalap-plant, in place of *Exogonium Purga*, one of the Convolvulaceæ. *M. dichotoma* is the Marvel of Peru, which is commonly cultivated in gardens. It is called in the West Indies "four o'clock flower," on account of opening its blossoms at that hour in the afternoon. Some of the species of *Pisonia* present a peculiar arrangement of the vascular bundles of the woody stem, which resembles in appearance that of Endogens.

984. Order 145.—**Amaranthaceæ,** the Amaranth Family. (*Apet. Hypog.*) Perianth 3-5-partite, hypogynous, scarious, persistent, usually with two bractlets at the base. Stamens hypogynous, either 5 and opposite the segments of the perianth, or double that number, distinct, or united, sometimes partly abortive; anthers either dithecal or monothecal. Ovary superior, single, 1-celled; ovules solitary or several, amphitropal, hanging from a free central funiculus; style 1, or 0; stigma simple or compound. Fruit a utricle or a caryopsis, rarely baccate. Seeds lentiform, pendulous; testa crustaceous; embryo peripherical; albumen farinaceous; radicle next the hilum.—Herbs and shrubs, with simple, opposite, or alternate exstipulate leaves; flowers

Fig. 685.—Fruit enclosed by the persistent and indurated base of the perianth.
Fig. 686.—The same cut vertically. *i*, Involucre. *c*, Perianth. *f*, Pericarp. *p*, Perisperm. *e*, Curved peripherical embryo, surrounding mealy albumen.
Fig. 687.—Horizontal section of the fruit. *c*, Perianth. *t*, Integument of the seed with the pericarp. *p*, Perisperm. *r*, Radicle. *c o*, Cotyledons.

in heads or spikes, usually hermaphrodite. They are natives of tropical and temperate regions. There are 47 known genera, and 500 species. *Examples*—Amaranthus, Achyranthes, Celosia, Deeringia, Gomphrena.

985. The plants are principally mucilaginous and demulcent. Many of them are known in cultivation, such as *Amaranthus hypochondriacus*, Prince's-feather; *A. caudatus*, Love-lies-bleeding; *Celosia cristata*, Cockscomb; *Gomphrena globosa*, Globe amaranth. *Amaranthus Blitum*, *A. oleraceus*, or Chusan Han-tsi, and other species, are used as pot-herbs. In the Cockscomb, the flowers form at the apex a peculiar crest of flattened or fasciated peduncles (fig. 230).

986. Order 146.—**Chenopodiaceæ**, the Goosefoot Family. (*Apet. Perigyn.* and *Hypogyn.*) Perianth deeply divided, sometimes tubular at the base, persistent, without bracts; æstivation imbricate. Stamens inserted into the base of the perianth or hypogynous, opposite to its segments, and equal to them in number, or fewer (fig. 544). Ovary single, superior, or sometimes cohering to the tube of the perianth, 1-celled; ovule solitary, attached to the base of the cell; style 2-4-parted; stigmas simple. Fruit membranous, indehiscent, enclosed in the calyx, sometimes fleshy. Seed erect or resupinate; embryo curved around farinaceous albumen, often like a horse-shoe, or spiral or doubled together without albumen; radicle next the hilum.—Herbs or undershrubs, with alternate, sometimes opposite, exstipulate leaves, and hermaphrodite or unisexual flowers. They are found in almost all parts of the world, but do not abound in the tropics. Most of the plants are inconspicuous weeds. There are 72 known genera, and 542 species. *Examples*—Chenopodium, Salicornia, Salsola, Atriplex, Beta, Basella.

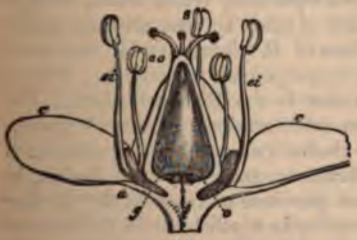
987. Many of the plants of this order are used as esculent potherbs, such as *Spinacia oleracea*, Spinage, *Beta vulgaris*, Beet, and var. *campestris*, Field Beet or Mangold Wurzel, *Atriplex hortensis*, Garden Orach, *Chenopodium Bonus Henricus*, English Mercury. The seeds of *Chenopodium Quinoa* are used as food in Peru, under the name of petty rice. The plant grows at a great elevation. Its leaves are used for spinage. They contain much starch and oil, combined with a bitter substance which appears to reside in the integuments. Many of the plants grow in salt marshes, and are called Halophytes (ἅλς, salt, and φυτὸν, a plant). They yield a quantity of soda. Among them may be enumerated species of *Salicornia*, *Salsola*, *Halimocnemis*, and *Kochia*. Beet-root yields a quantity of sugar. *Ambrina anthelmintica* yields a volatile oil, which is used in the cure of worms. Some of the *Chenopodiums* have a very fetid odour. The genus *Atriplex* has polygamous flowers, and was placed by Linnæus in his class polygamia. *Salvadora persica*, the true Mustard-tree, σίνηπι or σίναπι of Scripture, has been referred to this order. Lindley considers it the type of a new order in his Echial alliance. The tree grows in Syria,

and it has been found in Ceylon. Its root is acrid. Its succulent fruit has the taste of cresses, and its seeds are very small.

988. Order 147.—**Phytolaccaceæ,** the Phytolacca Family. (*Apet. Perigyn.*) Perianth 4-5-partite. Stamens usually perigynous, indefinite, or equal to the segments of the perianth, and alternate with them. Ovary of 1 or several carpels, distinct or combined; ovule 1 in each carpel, ascending or erect; styles equal to the carpels in number, terminal or lateral; stigmas simple or divided. Fruit fleshy and dry, indehiscent, sometimes samaroid. Seeds solitary, erect or ascending; embryo straight or curved; albumen mealy or 0; radicle next the hilum.—Undershrubs or herbs, with alternate, entire leaves, which are often dotted. They are natives both of tropical and warm countries, and are found in America, Asia, and Africa. The order has been divided into two suborders;—1. Phytolacceæ, with ascending seeds, embryo curved round mealy albumen, and exstipulate leaves. 2. Petiverieæ, with an erect seed, exalbuminous straight embryo, and stipulate leaves. There are 20 known genera, including about 84 species. *Examples*—Phytolacca, Rivina, Petiveria.

989. There is frequently much acridity in the plants of this order, and some of them act as irritant emetics and purgatives. The succulent fruit of *Phytolacca decandra,* common Poke, yields a red juice. It has been used as a remedy in cases of chronic syphilitic pains, and it possesses also emetic and purgative qualities. The plant is said to yield much potash. *Petiveria alliacea* is the Guinea-hen-weed, so called on account of these animals being fond of it.

990. Order 148.—**Polygonaceæ,** the Buckwheat Family. (*Apet. Hypog.* and *Perigyn.*) Perianth inferior (fig. 688 *c c*), divided, often coloured; æstivation imbricate (fig. 689). Stamens definite, inserted



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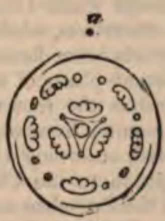

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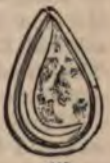

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Figs. 688-690.—Organs of fructification of Fagopyrum esculentum (Polygonum Fagopyrum), to illustrate the natural order Polygonaceæ.

Fig. 688.—Vertical section of the flower. *c c*, Perianth. *e e*, Outer stamens, which are introrse. *e i*, Inner stamens, which are extrorse. *a*, Glandular appendages. *o*, Ovary with its erect ovule, *g*. *s*, Styles and stigmas.

Fig. 689.—Diagram of the flower, showing five divisions of the imbricate perianth, stamens opposite the divisions, with glands and triangular unilocular ovary.

Fig. 690.—Seed cut vertically, showing the embryo with its superior radicle curved at one side of mealy albumen.

into the bottom of the perianth (fig. 688 *e e*, *e i*); anthers with longitudinal dehiscence. Ovary free (fig. 688 *o*), usually formed by 3 carpels, unilocular; ovule solitary, orthotropal (fig. 418); styles and stigmas equal to the carpels in number (fig. 688 *s*). Fruit a nut, usually triangular, naked or covered by the persistent perianth (fig. 271). Seed erect; albumen farinaceous; embryo antitropal, generally on one side (fig. 690), sometimes in the axis of the albumen; radicle superior (fig. 690).—Herbaceous, rarely shrubby plants, with alternate, stipulate, or exstipulate leaves, and often unisexual flowers. They are found in almost all parts of the world, more especially in the temperate regions of the northern hemisphere. They grow in fields, waste-grounds, ditches, mountains, &c. The order has been divided into two tribes:—1 Polygoneæ, with loose flowers, embryo usually abaxial (fig. 521), ochreate stipules (fig. 132). 2. Eriogoneæ, with involucrate flowers, embryo axial, leaves generally exstipulate. Authors enumerate 35 genera, including 500 species. *Examples*—Polygonum, Rumex, Rheum, Eriogonum.

991. The plants of this order have astringent and acid properties; some of them are purgative, and a few are acrid. Their astringency depends on the presence of tannin, and their acidity chiefly on oxalic acid. The root of *Polygonum Bistorta*, Bistort, so called on account of its double twist, contains much tannin, some gallic acid and starch, and is a powerful astringent. The leaves of *P. Hydropiper*, Water-pepper, are acrid and vesicant. *P. tinctorium* yields a blue dye. The fruit of *P. aviculare* is emetic and purgative. The fruit of *Fagopyrum esculentum*, and other species of Buckwheat, is used as food. The plant is cultivated in some northern countries. The leaves of *Rumex acetosa*, Common Sorrel, and of *R. Acetosella*, Field Sorrel, are acid and astringent. The roots of *Rumex aquaticus*, Water Dock, *R. Hydrolapathum*, Great Water Dock, and of other species, are used as astringents, and alteratives, while those of *R. alpinus*, under the name of Monk's-rhubarb, were formerly employed as purgatives. One of the most important plants of the order is the Rhubarb-plant. The officinal Rhubarb is the root of an undetermined species of *Rheum*. The extent of country from which rhubarb of one kind or another is actually collected, according to Christison, stretches from Ludak, in 77½° east longitude, to the Chinese province of Shen-si, 29° farther east, and from the Sue-chan mountains, in north latitude 26°, nearly to the frontiers of Siberia, 24° northward. The best rhubarb is said to come from the very heart of Thibet, within 95° east longitude, and 35° north latitude, five or six hundred miles north of Assam. The following are the species *Rheum* said to yield rhubarb:—

1. *Rheum palmatum*, L. This has perhaps the best title to be considered the true rhubarb-plant.
2. *Rheum undulatum*, L., which yields much of the French rhubarb.

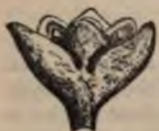
3. *Rheum compactum*, L. Another species yielding French rhubarb, and often cultivated in Britain for its acid petioles.
4. *Rheum Emodi*, Wall. This species yields a kind of Himalayan rhubarb. Its petioles are used for their acid properties.
5. *Rheum rhaponticum*, L. Used in France and Britain in the same way as the third species.
6. *Rheum hybridum*, Murr. Much cultivated in Germany for its root, and in Britain for its stalks.
7. *Rheum Webbianum*, Royle. A Himalayan species.
8. *Rheum spiciforme*, Royle. Another Himalayan species.
9. *Rheum Moorcroftianum*, Royle. Another Himalayan species.
10. *Rheum crassinervium*, Fisch. A Russian species.
11. *Rheum leucorhizum*, Pall. A Siberian and Altai species, said to yield imperial or White Rhubarb.
12. *Rheum Caspicum*, Fisch. A Capsian and Altai species.
13. *Rheum Ribes*, L. An Affghanistan and Persian species.

All these species grow in the cold parts of the world, as on the Altai mountains, in Siberia, Thibet, North of China, and on the Himalayan range. The rhubarb procured from one or more of these species, is known in commerce under the names of Russian or Turkey, Chinese or East Indian, and English rhubarb. Rhubarb contains raphides of oxalate of lime (¶ 18), along with tannin, gallic acid, resin, and a peculiar yellow-coloured principle called rhabarberin, which seems to be identical with chrysophanic acid. Raphides form from 35 to 40 per cent. of Turkey rhubarb, and give rise to its grittiness. These crystals are less abundant in the other varieties of rhubarb. Rhubarb is employed medicinally as a cathartic, astringent, and tonic, in the form of powder, pill, extract, tincture, wine, and infusion. *Coccoloba uvifera*, Sea-side-grape, so called from the appearance of its fruit, yields an astringent substance, called Jamaica Kino.

992. Order 149.—**Begoniaceæ**, the Begonia Family. (*Apet. Diclin.*) Flowers unisexual. Perianth coloured, having usually 4 divisions in the male flowers, and 5 or 8 in the female, some being smaller than others; æstivation imbricate. Stamens 00, distinct, or united into a solid column; anthers collected in a head, dithecal, with a thick connective, and longitudinal dehiscence. Ovary adherent to the tube of the perianth, winged, 3-celled, with three placentas meeting in the axis; ovules 00, anatropal; stigmas 3, sessile, 2-lobed, somewhat spirally twisted. Fruit a membranous, triangular, winged capsule, dehiscing below in a loculicidal manner. Seeds 00, minute; testa thin and reticulated; albumen 0; embryo oblong; radicle next the hilum.—Semi-succulent herbaceous plants and undershrubs, with alternate oblique leaves, having large scarious stipules. They are sometimes called Elephant's-ear, from the form of the leaves. They are natives of warm countries, as the East and West Indies, and South America. The stomata on the lower side of the leaves of many of the species of Begonia are arranged in clusters, and exhibit a beautiful

appearance under the microscope. Their leaves and young stems are acid, and have been used for tarts. Their roots are astringent and slightly bitter. *Begonia obliqua* is said to have purgative roots, and it is sometimes called wild rhubarb. There are 42 genera, and 170 known species. *Example*—Begonia.

993. Order 150.—**Lauraceæ**, the Laurel Family. (*Apet. Perigyn.*) Perianth with 4 or 6 divisions, which are usually in 2 rows (figs. 691, 692), the limb sometimes obsolete; æstivation imbricate (fig. 692). Stamens perigynous, definite, often twice as many as the divisions of the perianth, and arranged usually in two rows; those of the inner row (often three) being frequently sterile (staminodia), (fig. 693 *e s*), while those of the outer (often six in number) are fertile (figs. 692, 693 *e f*); if the inner stamens are fertile, they are extrorse, while the outer are introrse; filaments of the inner row often with glands at their base (figs. 325, 694 *g*); anthers 2-4-celled, cells opening by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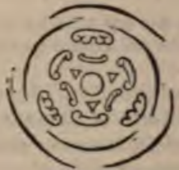
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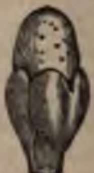
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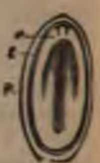

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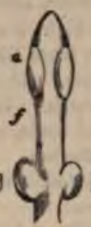

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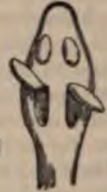
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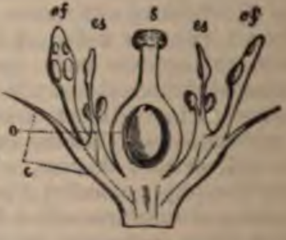

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Figs. 691-697.—Organs of fructification of Cinnamomum zeylanicum (Laurus Cinnamomum), to illustrate the natural order Lauraceæ.

Fig. 691.—Flower entire, with 6-divided perianth.

Fig. 692.—Diagram of the flower, with six imbricate divisions of the perianth; stamens in two rows, the outer six introrse, the inner three extrorse; glandular disk, and unilocular ovary.

Fig. 693.—The flower cut vertically. *c*, The perianth. *e f*, Fertile outer stamens with valvular introrse dehiscence. *e s*, Sterile inner stamens with glandular bodies. *o*, Monothecal ovary with pendulous ovule. *s*, Style, and obtuse stigma.

Fig. 694.—Stamen separated. *f*, Filament with two glandular bodies, *g g*, at its base. *a*, Anther with valves.

Fig. 695.—Anther viewed separately, showing its mode of dehiscence from below upwards by four longitudinal valves.

Fig. 696.—Fruit, which is succulent and partially enclosed in the persistent perianth.

Fig. 697.—The fruit deprived of the perianth, and cut vertically. *p*, Pericarp. *t*, Integument of the seed. *e*, Embryo.

longitudinal valves (figs. 325, 695). Ovary superior, unilocular (fig. 693 *o*); ovule solitary, pendulous (fig. 693); style simple; stigma obtuse (fig. 693 *s*). Fruit baccate or drupaceous, naked, or covered by the enlarged perianth (fig. 696); peduncle of the fruit sometimes becoming fleshy. Seed solitary, pendulous; albumen 0; embryo inverted (fig. 697 *e*); cotyledons large, plano-convex, peltate near the base; radicle very short, superior; plumule conspicuous. Trees, with exstipulate, alternate, rarely opposite leaves; sometimes twining, parasitic, and leafless herbs or undershrubs. They are natives chiefly of the tropical regions of Asia and America. Few are found in Africa. The order has been divided into two suborders:—1. Laureæ, true Laurels, trees with leaves. 2. Cassytheæ, Dodder-laurels, climbing parasitic plants without leaves. There are 56 known genera, and 470 species. *Examples*—Laurus, Cinnamomum, Persea, Nectandra, Tetranthera, Cassytha.

994. The plants of this order are in general aromatic and fragrant. Many of them yield volatile and fixed oils, others furnish camphor, and others have bitter and tonic barks. Some supply useful timber. *Laurus nobilis* is the Victor's-laurel, the leaves of which were used to crown the conquerors in battle, and in the Olympic games. It is probably the אֶזְרָח of the Bible. It is often called Sweet-bay, and is quite distinct from the common Bay, or Cherry-laurel (*Cerasus Laurocerasus*), both as regards structure and properties. It does not yield any hydrocyanic acid. The leaves and fruit are used medicinally as aromatic stimulants. The leaves contain a volatile oil, and the dark-coloured fruit yields, by expression, an odoriferous concrete oil of a green colour, called Oil of Bays. It is the only species found in Europe in a wild state. *Camphora officinarum* (*Laurus Camphora*), a native of China, Japan, and Cochin-China, is the Camphor-tree. Many plants supply a kind of Camphor, but the common camphor of the shops is the produce chiefly of this tree. All parts of the tree supply it, but it is obtained principally from the wood by distillation and subsequent sublimation. It is used in medicine as a sedative antispasmodic, in the form of mixture and tincture. The Borneo camphor has been noticed under the natural order Dipterocarpaceæ (¶ 789). *Sassafras officinale* (*Laurus Sassafras*), is an American tree, the root, wood, and flowers of which have been used in medicine. The root is prescribed in Britain as a warm aromatic stimulant and diaphoretic. It contains a volatile oil. A kind of Sassafras oil is procured from *Nectandra* or *Ocotea cymbarum* on the Casiquiare river in S. America. *Cinnamomum zeylanicum* (*Laurus Cinnamomum*), is the true Cinnamon-tree, cultivated in Ceylon. It attains the height of 30 feet. The bark of the tree constitutes the cinnamon of commerce, the קִנָּמֹן of the Bible. The young twigs about three years old furnish the best

cinnamon. The bark yields by distillation an oil, which is at first of a yellow colour, but soon assumes a reddish hue. The ripe fruit yields a concrete oil called cinnamon-suet. The root yields camphor. Cinnamon is administered as a tonic, stomachic, and carminative. The average importation of cinnamon into London is estimated at 500,000 pounds. The leaves of the cinnamon-tree are more or less acuminated; they have three principal ribs, which come into contact at its base, but do not unite; its young twigs are not downy, and its leaves have the taste of cloves. *Cinnamomum Cassia* or *aromaticum* (*Laurus Cassia*), seems to be the chief source of the Cassia lignea or Cassia-bark of commerce, the קִדָּה of the Bible. It differs from the true cinnamon in many particulars. Its leaves are oblong-lanceolate; they have three ribs, which coalesce into one at the base; its young twigs are downy, and its leaves have the taste of cinnamon. There is a fine specimen of the plant about twenty feet high in the Edinburgh Botanical Garden, which bears flowers regularly every year, and occasionally has produced fruit. Cassia-bark is imported from Canton through Singapore. It yields a yellow volatile oil called Oil of Cassia. Both the bark and oil are administered as aromatic stimulants. It is probable that Cassia buds, which consist of the flower-bud (perianth and ovary), are the produce of the Cassia-bark tree. They are used chiefly in confectionery, and they have the flavour and pungency of Cassia. Malabar Cassia appears to be the produce of another species of Cinnamomum, perhaps *C. eucalyptoides*. *Nectandra Rodiæi*, a large tree found in British Guiana, yields a bark known as the Bebeeru-bark. The wood of the tree is imported for ship-building, under the name of Green-heart. The bark was used by Dr. Rodie, who detected the existence of an alkaloid called Bebeerine. Dr. Douglas Maclagan obtained it pure, and found along with it another alkaloid called Sipeerine. Sulphate of Bebeerine is used as an antiperiodic. The cotyledons of the seed contain much starch, and are used for food. *Persea gratissima* (*Laurus Persea*) yields a pear-shaped succulent fruit called Avocado or Alligator-pear, or Subaltern's-butter. It contains a fixed oil. The clove nutmegs of Madagascar are produced by *Agathophyllum aromaticum*, and Brazilian nutmegs are the produce of *Cryptocarya moschata*. *Benzoin odoriferum* is the Spice-wood or Fever-bush of North America.

995. Order 151.—**Myristicaceæ**, the Nutmeg Family. (*Apet. Diclin.*) Flowers unisexual. Perianth trifid, rarely quadrifid, in the female deciduous; æstivation valvate. Stamens 3-12; filaments combined into a cylinder; anthers united or distinct, dithecal, ex-
rse, dehiscing longitudinally. Ovary free, composed of one or
carpels, unilocular; ovule solitary, erect, anatropal; style very
; stigma somewhat lobed. Fruit succulent, 1-celled, 2-valved.
solitary, usually covered by a laciniated arillus; embryo small,
tropal, at the base of ruminate albumen; cotyledons foliaceous;

radicle inferior.—Trees with alternate, exstipulate, entire, not dotted leaves. Natives of the tropical regions of Asia and America. There are 5 known genera, and between 30 and 40 species. *Example*—Myristica.

996. Acridity and aromatic fragrance are the properties of the order. The most important plant is ***Myristica officinalis*** (***M. moschata*** or ***aromatica***), a tree attaining a height of thirty feet, found in the Moluccas, and cultivated in many tropical countries. The fruit is drupaceous, and opens by two valves when ripe, displaying the beautiful reticulated scarlet arillus which constitutes mace. Within this is a thin, hard, dark-brown, glossy shell, covering the kernel, which is the nutmeg of the shops. It is said that a single tree will yield on an average about six pounds of nutmegs. By expression they are made to yield a concrete oil called *Adeps Myristicæ*, or sometimes erroneously oil of mace. A volatile oil is also procured by distillation. Mace is an arillode or additional covering of the seed commencing at the exostome (¶ 581). It has a fine crimson hue, and yields a fatty matter and volatile oil, resembling those of the nutmeg. Nutmeg and mace are used medicinally as aromatic stimulants and condiments. In large doses they have a narcotic effect. The fleshy part of the fruit is used as a preserve. The kernels of ***Myristica tomentosa*** are also used as aromatics, under the name of wild or male nutmegs. The bark of many plants of the order yields an acrid juice, which is sometimes of a crimson colour. A red pigment is furnished by ***Pyrrhosa tingens***.

997. Order 152.—**Proteaceæ**, the Protea Family. (*Apet. Perigyn.*) Perianth more or less deeply 4-divided; æstivation valvate. Stamens perigynous, 4 (1 sometimes sterile), opposite the segments of the perianth; anthers dithecal, with longitudinal dehiscence. Ovary single, superior, unilocular; ovules single or in pairs, anatropal or amphitropal; style simple; stigma undivided, discoid. Fruit dehiscent or indehiscent. Seed exalbuminous, sometimes winged; embryo straight; cotyledons 2 or more; radicle inferior, next the hilum.—Shrubs or small trees, with hard, dry, opposite or alternate, exstipulate leaves. They are natives principally of Australia and the Cape of Good Hope. In general they occur in land unfit for cultivation, and seldom attain to a considerable size. The order has been divided into two sections:—1. Nucumentaceæ, with nucumentaceous indehiscent fruit. 2. Folliculares, with follicular dehiscent fruit. Lindley mentions 46 genera, including 654 species. *Examples*—Protea, Persoonia, Grevillea, Hakea, Banksia, Dryandra.

998. The plants of this order have no medicinal properties of importance. They present great diversity of appearance, hence the name of the order, and they are cultivated for their handsome habit, and the peculiarity of their flowers. The clustered cone-like heads of the

flowers of *Banksias* have a remarkable appearance. In *Grevillea* the style is at first bent downwards, and the discoid stigma is enclosed within the upper part of the perianth, where the anthers are placed; but after the pollen has been scattered, the stigma is emancipated, and the style rises upwards. The fruit and seeds of a few plants of the order are eaten, and the wood is used for economical purposes. *Guevina Avellana* yields nuts, which are sold in Chili under the name Avellano. *Protea mellifera* is called Sugar-bush, on account of the honey furnished by its flowers. *Leucadendron argenteum* is the Silver-tree or Witteboom of the Cape. The bark of *Protea grandiflora*, called Wagenboom, is used by the Cape settlers in diarrhœa. It attains a height of 8-14 feet, and its wood supplies fuel at Simon's Town. *Grevillea robusta* is called Silver-oak.

999. Order 153.—**Elæagnaceæ**, the Oleaster Family. (*Apet. Diclis.* and *Perigyn.*) Flowers usually unisexual, rarely hermaphrodite. Male flowers amentaceous, with 2-4 leaves forming the perianth; stamens 3, 4, or 8; anthers nearly sessile, dithecal, introrse, and dehiscing longitudinally. In the female and hermaphrodite flowers, perianth tubular, persistent, with an entire or 2-4-toothed limb. Disk fleshy. Ovary superior, 1-celled; ovule solitary, ascending, on a short funiculus, anatropal; style short; stigma simple, subulate, glandular. Fruit a crustaceous achænium, enclosed within the enlarged succulent perianth. Seed ascending; embryo straight, surrounded by thin fleshy albumen; cotyledons fleshy; radicle inferior.—Trees or shrubs, with alternate or opposite, entire, exstipulate leaves, which are often covered with scurfy scales (fig. 83). They are found in all parts of the northern hemisphere. They have no marked medicinal properties. The fruit of some is eaten. *Hippophaë rhamnoides*, Sea Buckthorn, is furnished with sharp spines, and forms a good hedge near the sea. Its fruit is eaten, although it is said by some to have narcotic qualities. The plant yields a yellow dye. The fruit of *Elæagnus parvifolia* is eaten. Its flowers are highly fragrant, and abound in honey, which is esteemed as a remedy for malignant fevers in some parts of Europe. There are 4 known genera, and 30 species. *Examples*—Elæagnus, Hippophaë.

1000. Order 154.—**Penæaceæ**, the Sarcocol Family. (*Apet. Perigyn.*) Perianth coloured, salver-shaped, with a 4-lobed limb, and with two or more bracts at its base, persistent. Stamens perigynous, either 4 or 8, alternate with the lobes of the perianth; anthers dithecal, introrse. Ovary superior, 4-celled; ovules usually in pairs, collateral, anatropal, ascending or suspended; style simple; stigmas 4. Fruit a 4-celled, 4-valved capsule. Seed erect or pendulous; testa brittle; hilum with a fungus-like aril; nucleus a fleshy mass, without distinction of albumen or embryo.—Shrubs, with opposite, entire, exstipulate leaves. They are found at the Cape of Good Hope. They have no known

rties of importance. The gum-resin called Sarcocol is said to be
ıced on the perianth of *Penæa Sarcocolla*, and other species.
are two sections of this order:—1. Penæeæ, æstivation valvate,
ns 4, connective fleshy, ovules ascending. 2. Geissolomeæ, æsti-
ı imbricate, stamens 8, connective not fleshy, ovules suspended.
are 6 known genera, and 21 species. *Examples*—Penæa, Geis-
a.

)1. Order 155.—**Thymelæaceæ**, the Daphne Family. (*Apet.
yn.*) Perianth tubular, coloured, 4- rarely 5-cleft, inferior;
ionally with scales in its orifice; æstivation imbricate. Stamens
ynous, definite, often 8, sometimes 4 or 2 and then opposite the
ents of the perianth; anthers dithecal, with longitudinal dehis-
. Ovary free, 1-celled; ovule suspended, anatropal (fig. 426);
1; stigma undivided. Fruit either nut-like or drupaceous.
solitary, pendulous; albumen 0, or thin and fleshy; embryo
ht; cotyledons plano-convex, or somewhat lobed and shrivelled;
e superior.—Shrubby, rarely herbaceous plants, with alternate,
posite, entire, exstipulate leaves. Natives of various parts of the
, both in warm and temperate regions. There are two sections
e order:—1. Daphneæ, with hermaphrodite or rarely unisexual
rs, and plano-convex cotyledons. 2. Hernandieæ, with poly-
us flowers, and lobed and shrivelled cotyledons. Authors enu-
e 43 genera, including 310 species. *Examples*—Daphne (Thy-
a), Passerina, Pimelea, Gnidia, Lagetta, Exocarpus, Hernandia,
rpus.

)2. The bark of many of the plants is acrid and irritant, the
is often narcotic. The bark of the root, as well as that of the
hes of *Daphne Mezereum*, Mezereon, is used in decoction as a
oretic in cutaneous and syphilitic affections. In large doses it
s an irritant poison, causing hypercatharsis; and, when applied
nally, it acts as a vesicant. It contains a neutral crystalline
iple called Daphnein. The succulent fruit is also poisonous. The
of *Daphne Gnidium*, *D. alpina*, *D. Cneorum*, *D. pontica*, and *D.
eola*, Spurge-laurel, have similar properties. The berries of
ne Laureola are poisonous to all animals except birds. The fruit
rca palustris, Leather-wood, is said to be narcotic. The bark of
of the plants is made into ropes and paper (fig. 101). The inner
of *Lagetta lintearia* (*Daphne Lagetta*,) when cut into thin pieces
maceration, assumes a beautiful net-like appearance, whence it
eceived the name of Lace-bark. The bark, young leaves, and
of *Hernandia*, are slightly purgative. The seeds of *Inocarpus*
have the taste of chestnuts, and are eaten when roasted.

03. Order 156.—**Aquilariaceæ**, the Aquilaria Family. (*Apet.
yn.*) Perianth coriaceous, imbricate or tubular, limb 4-5-lobed;
ation imbricate. Stamens usually 10 fertile, alternating with 10

sterile, in the form of petaloid scales, sometimes 8 or 5; filaments inserted into the orifice of the perianth, often united; anthers dithecal, with longitudinal dehiscence. Ovary free, ovate compressed, 2-celled; ovules 2, suspended, anatropal; stigma usually sessile, large and simple. Fruit a pyriform, sessile, or stipitate 2-valved capsule, or drupaceous and indehiscent. Seeds 2, one on each placenta, pendulous; albumen 0; cotyledons fleshy, hemispherical; radicle straight, superior. —Trees, with alternate or opposite, entire, stalked, and exstipulate leaves. They are natives of the tropical regions of Asia. They have no known medical properties. *Aquilaria ovata* and *Agallochum* furnish a fragrant wood called Eagle-wood, or Aloes-wood. It is probably the אֲהָלִים, the trees of Aloes or Lign-Aloes, of the Bible, yielding an aromatic perfume. It has been considered a cordial by some Asiatic nations, and has been prescribed in Europe in gout and rheumatism. There are 7 genera noticed, including 12 species. *Examples* —Aquilaria, Gyrinopsis.

1004. Order 157.—**Chailletiaceæ,** the Chailletia Family. (*Apet. Perigyn.*) Perianth 5-parted, with an incurved valvate æstivation. Stamens inserted into the base of the perianth, 5 inner fertile opposite the segments of the perianth, 5 outer sterile, petaloid, usually with glands at their base; anthers ovate, versatile, dithecal. Ovary free, 2- 3-celled; ovules twin, pendulous; styles 2-3, distinct or combined; stigmas capitate or obscurely 2-lobed. Fruit dry, 1- 2- or 3-celled. Seeds solitary, pendulous, exalbuminous; embryo thick; cotyledons fleshy; radicle superior.—Trees or shrubs, with alternate, stipulate leaves, and axillary peduncles, often cohering to the petiole. They are natives of the warm parts of Africa and South America. The fruit of *Chailletia toxicaria* is said to be poisonous; it is called Ratsbane in Sierra Leone. There are 4 genera, and 10 species known. *Examples*—Chailletia, Tapura.

1005. Order 158.—**Samydaceæ,** the Samyda Family. (*Apet. Perigyn.*) Perianth 4-5-divided, usually coloured inside; æstivation somewhat imbricate. Stamens inserted into the tube of the perianth, 2, 3, or 4 times as many as its divisions, either all fertile, or the alternate ones sterile, shorter and fringed; filaments monadelphous at the base; anthers erect, ovate, 2-celled. Ovary free, 1-celled; ovules 00, attached to parietal placentas, semi-anatropal; style 1, filiform; stigma capitate or slightly lobed. Fruit a coriaceous, unilocular, 3-5-valved capsule, partially dehiscent. Seeds 00, fixed irregularly on the pulpy inner surface of the valves, with a fleshy arillus, and a hollowed hilum; embryo large, in the midst of oily or fleshy albumen; cotyledons ovate, foliaceous; radicle pointing to the extremity remote from the hilum.—Trees or shrubs, with alternate, simple, stipulate leaves, usually having pellucid, round, or linear markings. Natives of tropical regions, chiefly in America. Some of the species of *Casearia* are bitter and astringent. A decoction of the leaves of *Casearia Lingua*, called by the Brazilians Cha de Frade and Lingua de Fin, is also used internally in inflammatory disorders and malignant fevers. There are 6 known genera, and 82 species. *Examples*—Samyda, Casearia.

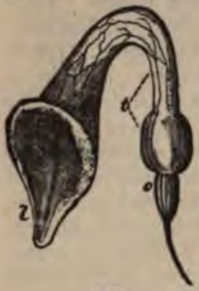
1006. Order 159.—**Homaliaceæ**, the Homalia Family. (*Apet. Perigyn.*) Perianth funnel-shaped, with 5 to 15 divisions, and having usually alternating petaloid segments, and glands or scales in front of the outer divisions. Stamens perigynous, either single or in parcels of 3 or 6, alternating with the outer divisions of the perianth; anthers dithecal, with longitudinal dehiscence. Ovary partly adherent to the tube of the perianth, 1-celled; ovules numerous, anatropal, pendulous, attached to 2, 3, or 5 parietal placentas; styles 3-5, simple, filiform, or subulate. Fruit either baccate or capsular. Seeds small, ovate; embryo in the axis of fleshy albumen; cotyledons leafy; radicle superior.—Trees or shrubs, with alternate leaves, having deciduous stipules. Many look upon the petaloid division of the perianth as true petals. Lindley puts this order in his Cactal alliance, and considers it as allied to Loasaceæ. It contains tropical plants, which do not possess any important properties. Authors mention 9 genera, including 32 species. *Examples*—Homalium, Nisa.

1007. Order 160.—**Santalaceæ**, the Sandal-wood Family. (*Apet. Epigyn.*) Perianth superior, 4-5-cleft; æstivation valvate. Stamens 4-5, opposite the segments of the perianth, and inserted into their bases. Ovary coherent, 1-celled; ovules 1-4, pendulous from the apex of a central placenta; style 1; stigma often lobed. Fruit nut-like or drupaceous. Seed solitary; embryo minute, in the axis of fleshy albumen; radicle superior.—Trees, shrubs, or herbs, with alternate or nearly opposite exstipulate leaves. Found in various parts of the world, as Europe, Asia, America, and New Holland. Authors give 21 genera, including 115 species. *Examples*—Santalum, Osyris, Thesium.

1008. Some are astringent, others yield fragrant wood. *Santalum album*, and other Indian and Polynesian species, yield Sandal-wood, which is used both medicinally and as a perfume. The seeds of some of the plants of the order are eaten. The species of *Thesium* seem to be root-parasites. The large seeds of *Pyrularia oleifera*, Buffalo-tree, or Oil-nut, yield a fixed oil.

1009. Order 161.—**Aristolochiaceæ**, the Birthwort Family. (*Apet. Epigyn.*) Perianth adherent, tubular, 3-cleft (fig. 699), regular or sometimes very irregular (fig. 698); æstivation valvate or induplicate. Stamens 6-12, epigynous, distinct or gynandrous (fig. 701). Ovary inferior, 3-6-celled (figs. 700, 702); ovules 00 (fig. 700), anatropal, horizontal; style simple, short; stigmas radiating, 3-6 (fig. 701 *s*). Fruit dry or succulent, 3-6-celled (fig. 703). Seeds (fig. 704) numerous; embryo very minute, at the base of fleshy albumen (fig. 705);

cotyledons inconspicuous; radicle next the hilum (fig. 706).—Herbs or shrubs, often climbing, with alternate, simple, often stipulate leaves,



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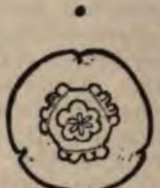

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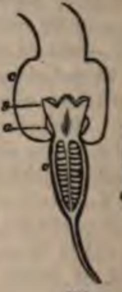

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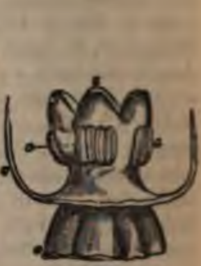

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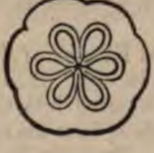

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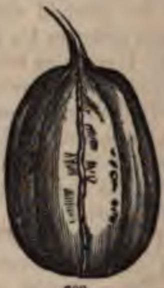

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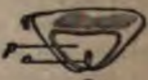

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706

and solitary axillary flowers. Found in abundance in the warm regions of South America, and growing also in the temperate and cold regions of Europe, Asia, and America. There are 10 known genera, and 134 species. *Examples*—Asarum, Aristolochia.

1010. The plants of the order are generally bitter, tonic, and stimulant. Some are acrid, and act as emetics. The leaves of *Asarum europæum* are used as an acrid emetic under the name of Asarabacca.

Figs. 698-706.—Organs of fructification of Aristolochia Clematitis, to illustrate the natural order Aristolochiaceæ.

Fig 698.—Flower entire, consisting of an inferior ovary, and a superior, irregular, funnel-shaped perianth. *o*, Part of the perianth adherent to the ovary. *t*, Part of the tube of the perianth, with a swollen portion at the base, enclosing the anthers and stigma. *l*, Limb of the perianth prolonged laterally in a tongue-like form.

Fig. 699.—Diagram of the flower, showing three divisions of the perianth, six anthers, and six cells of the ovary.

Fig. 700.—Lower part of the flower cut vertically. *o*, Ovary with numerous ovules. *t*, Radiating stigma. *a*, Anthers. *c*, Swollen part of the tube of the perianth.

Fig. 701.—*s*, Stigma with the anthers adhering to the column in pairs. *o*, Summit of the ovary. *c*, Swollen part of the tube of the perianth.

Fig. 702.—Horizontal section of the six-celled ovary.

Fig. 703.—Ripe fruit. Fig. 704.—Angular seed.

Fig. 705.—Seed cut vertically. *t*, Integument thickened near the chalaza. *p*, Fleshy perisperm. *e*, Minute embryo.

Fig. 706.—Embryo separated, with cotyledons and radicle.

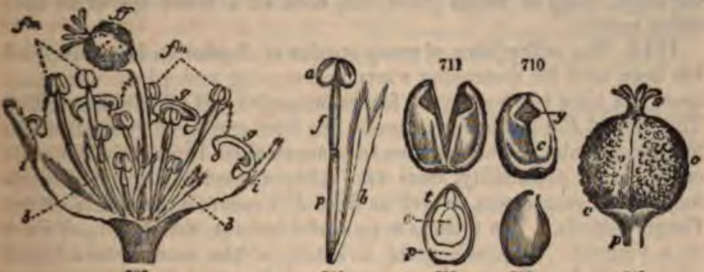
The roots appear to have greater activity than the leaves. The powdered root and leaves enter into the composition of cephalic snuffs, which cause sneezing by their irritation, and are used in cases of headache and ophthalmia. An active crystalline substance, called Asarin, exists in the plant. *Asarum canadense*, Wild Ginger, or Canada Snake-root, is used as a spice in Canada. The shrubby species of *Aristolochia* have a peculiar arrangement of vascular bundles in their wood. There are no concentric zones, but a number of separable wedges (¶ 90). The name of Birthwort, given to Aristolochias, depends on their supposed action on the uterus. Some of them are used as emmenagogues. The root of *Aristolochia serpentaria*, Virginian Snake-root, is a stimulant tonic. The plant is a native of the United States. It was formerly used as an antidote to snake-poison. It is now employed occasionally as a tonic diaphoretic. *Aristolochia longa*, *rotunda*, and *Clematitis*, were celebrated in ancient times as uterine remedies. The roots of many of the species have a strong aromatic taste. Those of *Aristolochia anguicida* are said to stupify snakes.

1011. Order 162.—**Nepenthaceæ**, the Pitcher-plant Family. (*Apet. Diclin.*) Flowers diœcious. Perianth 4-parted, inferior; æstivation imbricated. Male flowers: stamens united in a solid central column; anthers about 16, forming a spherical head, extrorse, and with longitudinal dehiscence. Female flowers: ovary free, four-cornered, 4-celled; ovules 00; stigma sessile. Fruit a 4-celled, 4-valved capsule, with loculicidal dehiscence. Seeds 00, ascending, very minute, fusiform, with a loose testa; nucleus less than the seed, suspended by the chalaza; embryo in the midst of fleshy albumen; cotyledons plano-convex; radicle pointing to the hilum.—Herbs, or half-shrubby plants, with alternate leaves, slightly sheathing at the base, having a foliaceous petiole, which forms an ascidium at its extremity, and the lamina in the form of a lid (fig. 184). Natives of swampy ground in the East Indies and China. They have no known properties. The pitchers have been found to contain a solution of binoxalate of potash. Some chemists have detected muriate of soda, malic, and other acids in them. Spiral vessels abound in all parts of the pitcher plants; and the woody bundles are without concentric zones. Lindley gives 1 genus, and 8 species. *Example*—Nepenthes.

1012. Order 163.—**Datiscaceæ**, the Datisca Family. (*Apet. Diclin.*) Flowers unisexual. Male flowers: perianth 3-4-divided. Stamens 3-7; anthers linear, membranous, dithecal, with longitudinal dehiscence. Female flowers: perianth adherent, 3-4-toothed. Ovary inferior, unilocular; ovules 00, anatropal, attached to 3 or 4 parietal placentas; styles as many as the placentas. Fruit a 1-celled capsule, opening at the apex. Seeds 00, strophiolate, with a reticulated spermoderm; albumen 0; embryo straight; cotyledons very short; radicle pointing to the hilum.—Herbaceous branched plants or trees, with alternate, exstipulate leaves. They are scattered over North America, various parts of Asia, and the south-eastern part of Europe. Some of the plants are said to be bitter, and others of them have purgative qualities. It has been stated that female plants of *Datisca cannabina* have produced seed without the application of pollen. Facts are still wanting to prove this. Lindley mentions 3 genera, and 4 species. *Examples*—Datisca, Tetrameles.

1013. Order 164.—**Empetraceæ**, the Crowberry Family. (*Apet. Diclin.*) Flowers unisexual. Perianth bud-like, consisting of persistent imbricated scales, in 2 or 4 alternating rows, the inner row often petaloid. Male flowers: stamens 2-3, equal in number to the scales in each row, and alternating with the innermost, hypogynous; anthers roundish, dithecal, with longitudinal dehiscence. Female flowers: ovary free, seated on a fleshy disk, 3- 6- or 9-celled; ovules solitary, anatropal, ascending; style 1; stigma with as many radii as there are ovarian cells. Fruit a nuculanium, seated within the persistent perianth. Seeds solitary in each nucule, ascending; embryo in the axis of fleshy albumen; radicle inferior.—Heath-like shrubs, with alternate or somewhat verticillate, evergreen exstipulate leaves. They inhabit chiefly Europe and North America. The fruit of some is slightly acid. *Empetrum nigrum*, the black Crowberry, is common on the mountainous and northern parts of Europe. The fruit is watery, and very slightly acid and astringent. Lindley notices 4 genera, and 4 species. *Examples*—Empetrum, Corema.

1014. Order 165.—**Euphorbiaceæ**, the Spurge Family. (*Diclin.*) Flowers unisexual, sometimes enclosed within an involucre (fig. 707). Perianth lobed, inferior (figs. 314 *c*, 317 *c*), with various glandular or petaloid, scaly, internal appendages (figs. 314 *p a*, 405); sometimes the flowers are naked (fig. 708). Male flowers (fig. 707 *fm fm*); stamens definite or 00, distinct (fig. 708) or monadelphous (fig. 314, 1), or polyadelphous (fig. 317); anthers bilocular, sometimes with porous dehiscence (fig. 323). Female flowers (figs. 405, 707 *f f*): ovary free, sessile or stalked, 1-2-3- or many-celled (fig. 709); ovules solitary or twin, suspended; styles equal in number to the cells (figs. 314, 2, 709 *s*), distinct or combined, sometimes 0; stigmas several, or 1 with several lobes. Fruit usually tricoccous (figs. 447, 453), with the cocci separating in an elastic manner, and opening by 2 valves (figs. 710, 711), or indehiscent and fleshy. Seeds solitary (fig. 712) or in pairs, suspended, often arillate (fig. 453 *g g*); embryo enclosed in fleshy albumen (fig. 483); cotyledons flat (fig. 509); radicle superior (fig. 713). —Trees, shrubs, and herbs, often abounding in acrid milk, with opposite or alternate, often stipulate leaves, sometimes none. Some look on this order as apetalous, with a tendency to develop a corolla, while others consider it polypetalous, with a tendency to have the corolla suppressed. In European plants of the order there are usually no petals present, but in those of tropical countries the corolla is frequently well marked. In the Euphorbias of Britain, there is an evident involucre, surrounding a number of achlamydeous male and female flowers, which by Linnæus were looked upon as merely stamens and pistils, and hence the plants were put by him in Dodecandria in place of Monœcia (see ¶ 401). The flowers in Euphorbiaceæ vary much in the number of their parts, as may be seen in figs. 545-550. Sometimes the general peduncle or rachis becomes flattened and leaf-like (fig. 229). The inflorescence is occasionally amentaceous, as in the division *Scepaceæ*, which is separated, as a distinct but not fully defined order, by Lindley. The plants of the order abound in warm regions, especially in Equinoctial America, where they occur as trees or bushes, or lactescent herbs, and often present the appearance of Cactuses, from which their milky juice at once distinguishes them. They are also found in North America and in Europe. In Britain there are 18 species. There are about 222 known genera, and upwards of 2,900 species. *Examples*—Euphorbia, Hippomane, Hura, Acalypha, Croton, Jatropha, Ricinus, Phyllanthus, Buxus.



707 708 713 712 709

1015. The plants of this order are acrid and poisonous, in some instances furnished with stinging hairs. These properties reside especially in their milky juices, which are contained in laticiferous

Figs. 707-713.—Organs of fructification of Euphorbia palustris, to illustrate the natural order Euphorbiaceæ.

Fig. 707.—Inflorescence, with the involucre, *i i*, opened and spread out, to show the position of the male and female flowers which it encloses. *g g*, Glands (glandular lobes) alternating with the divisions of the involucre. *b b*, Membranous laminæ, or bracts, at the base of the flowers. *f m, f m*, Achlamydeous male flowers, consisting of a single stamen, supported on a pedicel, to which it is attached by an articulation. *f f*, Achlamydeous female flower in the centre; the ovary and styles supported on a long pedicel.

Fig. 708.—Achlamydeous male flower separated. *b*, Bract. *p*, Pedicel. *f*, Filament articulated with the pedicel. *a*, Anther.

Fig. 709.—Female flower. *p*, Summit of the pedicel which supports it. *c*, A flattened portion of the pedicel, which some call a perianth. *o*, Tricoccous ovary. *s*, Styles and stigmas.

Fig. 710.—One of the cocci (carpels), *c*, separated, and seen on its inner surface. *g*, The seed seen across the opening by which the nourishing vessels enter.

Fig. 711.—A coccus separated, after dehiscence and expulsion of the seed.

Fig. 712.—Seed separated.

Fig. 713.—Seed cut vertically. *t*, Integument (spermoderm). *p*, Perisperm (fleshy albumen *e* Embryo with flat cotyledons, and a superior radicle.

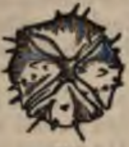
vessels (fig. 66), in which the movements of Cyclosis were observed by Schultz (¶ 262). In many cases the elaborated sap contains caoutchouc and resin. The acrid properties of the order are also found in the seeds, many of which yield oils, both of a bland and of an irritating nature.

1016. The milky juice of many species of *Euphorbia* is caustic, and has been used for destroying warts, and causing vesication. At other times the juice has been used for its purgative and emetic properties. The root of *Euphorbia Ipecacuanha* has been employed as a substitute for Ipecacuanha. The resinous substance called Euphorbium is procured, in all probability, from two African species, *Euphorbia officinarum* and *antiquorum*, as well as from *E. canariensis*, a native of the Canary islands. The resin is a powerful irritant, and has been used as a vesicant. It causes great irritation of the mucous membrane when applied to the nostrils and eyes, and it acts as a cathartic when taken internally. Many species of Euphorbia yield resins of a similar nature. The juice of *Hippomane Mancinella*, Manchineel, is very acrid and poisonous. When applied to the skin, it excites violent inflammation, followed by ulceration. The juice of *Hura crepitans*, Sandbox-tree, or Monkey's dinner bell, is also very acrid. The fruit of this tree is composed of numerous 1-seeded cocci, which, when dry, separate from each other with great force. *Mercurialis perennis*, and *annua*, produce vomiting and purging.

1017. Many important medicinal oils are furnished by the plants of this order. Castor-oil is expressed from the seeds of *Ricinus communis* (*Palma Christi*), a plant with peltate-palmate leaves (fig. 146), which is found native in Greece, Africa, and the East Indies, and is cultivated in the West Indies, as well as in North and South America. In the temperate and more northern parts of Europe, the plant is a herbaceous annual of from three to eight feet high; in the more southern parts it becomes shrubby, and even attains a height of twenty feet; while in India it is often a tree thirty or forty feet high. The best oil is got by expression from the seeds without heat, and is called cold-drawn Castor-oil. It is entirely soluble in alcohol, and, by the action of hyponitrous acid, it is converted into a solid yellow substance called Palmin. The oil acts as a mild laxative. Besides this comparatively bland oil, there exists in the seed a powerfully cathartic constituent, which remains behind when the oil is expressed, and which is destroyed or evaporated under the process of ebullition. Croton-oil is obtained by expression from the seeds of *Croton Tiglium*, an Indian and Asiatic shrub. It acts as an irritant purgative in the dose of one drop. In large doses it is a dangerous poison. When applied externally it produces pustules. Other species of Croton, as *C. Pavana* and *Roxburghii*, yield a purgative oil. The oil procured from the seeds of *Euphorbia Lathyris*, Caper-spurge, has cathartic properties, and so has that procured from the seeds of *Jatropha Curcas* (*Curcas purgans*), Physic or purging-nut, *Jatropha multifida*, and *Hura crepitans*. The fatty matter obtained from the seeds of *Stilingia sebifera*, the Tallow-tree of China, is used for making candles; the plant also yields a bland oil. The roots of *Euphorbia pilosa* and *palustris* are used as purgatives, and are said to have been useful in hydrophobia.

1018. Cascarilla is the bark of *Croton Eleuteria*, and of other species of Croton. It acts as a tonic and stimulant. When burned it gives out a musky odour, and is often used in pastilles. The bark of another species of Croton (*C. pseudo-quina*), is known by the name of Copalchi bark, and used as a tonic. The bark of *Buxus sempervirens*, Box-tree, is said to be alterative, and its leaves have bitter and purgative qualities. Its wood is much used for wood-engraving. The hard wood called African Teak or African Oak is the produce of *Oldfieldia Africana*. In the root of *Janipha Manihot* (*Manihot utilissima*), a shrub about six feet high, extensively cultivated in tropical countries, there is much starchy matter deposited, usually along with a poisonous narcotic substance, which is said to be hydrocyanic acid. The latter can be removed by washing, or it can be driven off by roasting, and then the starch is used in the form of Cassava bread. There are two varieties of the Cassava or Manioc plant; one (called sometimes *Janipha Lœflingii*) having a spindle-shaped root, brown externally, about six ounces in weight, which contains amylaceous matter, without any bitterness, and is used as food under the name of Sweet Cassava; another, called Bitter Cassava, having a knotty root, black externally, and sometimes 30 lbs. in weight, which is bitter and poisonous, and requires to be rasped and washed thoroughly before the amylaceous matter can be used. From the starch of the bitter Cassava, Tapioca is prepared by elutriation and granulating on hot plates. Manihot starch is sometimes imported into Europe under the name of Brazilian Arrow-root. The milky sap of *Euphorbia phosphorea* is said to emit a peculiar phosphorescent light. That of *Siphonia elastica* contains much caoutchouc, and supplies the bottle India-rubber. *Aleurites laccifera* furnishes gum-lac in Ceylon. *Crozophora tinctoria* supplies a purple dye called Turnsole, which becomes blue on the addition of ammonia. The seeds of a few species of *Aleurites*, *Anda*, and *Omphalea* are edible. It is said that, in some instances, the elaborated sap has poisonous properties, while the ascending sap is innocuous (¶ 263). A species of Cœlebogyne is stated to have produced perfect seeds without the application of pollen (¶ 501).

1019. Order 166.—**Urticaceæ**, the Nettle Family. (*Apet. Diclin.*) Flowers unisexual (fig. 716), hermaphrodite or polygamous, scattered, or collected into catkins or heads. Perianth usually divided (fig. 716). Stamens definite, inserted into the perianth; filaments sometimes curved in æstivation (fig. 715). Ovary free (figs. 717, 718), rarely coherent, 1-2-celled; ovule solitary, erect (fig. 718), or suspended; stigmas 1 or 2, simple or bifid (fig. 718). Fruit an indehiscent nut, surrounded by the persistent pericarp, or a samara, or a syconus, or a sorosis (figs. 245, 246, 475). Seed solitary, erect, suspended, or pendulous, albuminous, or exalbuminous; embryo straight, or curved, or spiral; radicle superior (figs. 719, 720).—Herbs, shrubs, or trees, with alternate, stipulate leaves, which are usually hispid or scabrous. This order has been divided into the following suborders:—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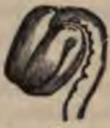
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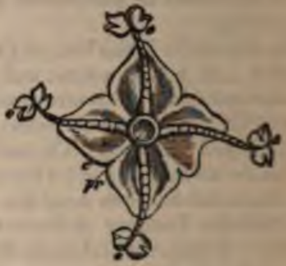

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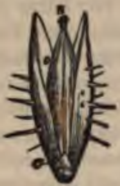

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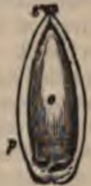

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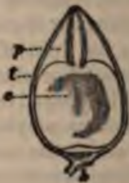

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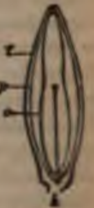

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Figs. 714-720.—Organs of fructification of Urtica urens, to illustrate the natural order Urticaceæ, section Urticeæ.

Fig. 714.—Bud of the male flower, viewed from above.

Fig. 715.—Stamen taken from the bud of the male flower, with the elastic incurved filament, and the anther bent down before dehiscence.

Fig. 716.—Male flower expanded. *c*, Perianth with four divisions. *e e e e*, Four hypogynous stamens, thrown back by the elasticity of the filaments, with the anthers burst. *p r*, A hollow rudiment of the central pistil.

Fig. 717.—Female flower. *c*, Perianth with four unequal segments, the two exterior ones being very small. *o*, Unilocular ovary. *s*, Sessile stigma.

Fig. 718.—Pistil cut vertically, to show the direction of the erect ovule, *e*. *p*, Parietes of the ovary. *s*, Stigma.

Fig. 719.—Seed cut vertically, parallel to the cotyledons. *t*, Integument (spermoderm). *h*, Hilum. *p*, Perisperm. *e*, Embryo straight, with the radicle superior.

Fig. 720.—Seed cut perpendicularly to the cotyledons. *t*, Integument. *h*, Hilum. *p*, Perisperm. *e*, Embryo.

1. Urticeæ, True Nettles (figs. 714-720): rough-leaved plants, often with stinging hairs, filaments elastic, and curved in æstivation (fig. 715); fruit an indehiscent nut; seed erect, albuminous; embryo straight; juice watery. They are widely scattered over the globe, and many of them follow the footsteps of man in his migrations.
2. Cannabineæ, Hemp tribe: scabrous plants with erect filaments; fruit indehiscent; seed suspended, exalbuminous; embryo hooked or spiral; juice watery. They occur chiefly in temperate regions.
3. Ulmaceæ, Elm tribe: rough-leaved trees or shrubs, filaments erect in æstivation; fruit 1-2-celled, samaroid or drupaceous; seed pendulous, usually exalbuminous; embryo straight or curved; juice watery. Natives of the northern and mountainous parts of Europe, Asia, and America.
4. Moreæ, Mulberry tribe: usually rough-leaved trees or shrubs; filaments erect in æstivation; fruit a sorosis or syconus (figs. 246, 475); seed solitary, pendulous, albuminous; embryo hooked; juice milky. Natives of temperate and tropical regions.
5. Artocarpeæ, Bread-fruit tribe: trees or shrubs, with leaves often rough; filaments generally erect in æstivation; fruit often a sorosis; seed erect or pendulous, albuminous; embryo straight; juice milky. Natives of tropical regions.

There are about 104 known genera, and about 650 species. *Examples*—Urtica; Cannabis, Humulus; Ulmus, Celtis; Morus, Ficus, Dorstenia; Artocarpus, Antiaris.

1020. The properties of the order are various. Many yield valuable fibres, others supply important edible fruits, others furnish caoutchouc, and others form important forest trees. Various species of *Urtica*, Nettle, such as *U. dioica*, *urens*, *pilulifera*, *stimulans*, *crenulata*, and *urentissima*, have stinging hairs (fig. 86). The young shoots of the common nettle are sometimes used like spinach or greens. *Urtica cannabina* and *tenacissima* furnish fibres fit for cordage *Bœhmeria nivea* supplies fibre for the Chinese grass-cloth, and *Bœhmeria Puya* gives the Pooah or Puya fibre of Nepal and Sikkim. In Nettles and Pellitories, the elastic filaments turn the anthers back with elasticity, and cause the scattering of the pollen (¶ 497). Specimens of Tree-nettle, *Urtica gigantea*, were measured by Backhouse in Australia, and found to be 18, 20, and 21 feet in circumference. Their sting is very severe, causing violent inflammation. *Cannabis sativa* is the source of the valuable fibre called Hemp. A variety called *Cannabis indica* is used in India for producing intoxication. It is also employed medicinally in the form of extract, as an antispasmodic and anodyne, in cases of tetanus and neuralgia. The properties of the hemp plant appear to be much modified by climate. The Indian variety has a marked resinous varnish, called Churrus, on its leaves. What is called Bhang in India, consists of the dried larger leaves and fruit, while Gunjah is the whole plant dried after flowering, and the Haschisch of the Arabs is composed of the tops and tender parts of the plant dried. The strobili of the female plants of *Humulus Lupulus* constitute hops, the bitterness of which resides in the resinous glandular scales surrounding the fruit, and to which the name of Lupulinic glands, or Lupulin, has been applied. The latter name is also given to the bitter principle of the hops. Hops are employed as a tonic and narcotic, in the form of extract, infusion, and tincture. Their tonic properties depend on their bitterness. A pillow stuffed with hops is a popular means of procuring sleep. The twigs of hops have been used to adulterate Sarsaparilla. Several species of Elm are cultivated for timber. *Ulmus campestris*, English or small-leaved Elm, rarely produces fruit in this country. It often attains a height of 70 to 90 feet, with a diameter of 4 to 5 feet. Its wood is compact and durable under water, and it has been used for sleepers on railways, and for wooden pavements. Its inner bark is bitter, mucilaginous, and astringent. *Ulmus montana*, the Mountain, Wych, or Scotch Elm, produces fruit freely in this country, but its wood is inferior to that of the English Elm. *Celtis*, the Nettle-tree, or Sugar-berry, has a sweet drupaceous fruit.

1021. The common Fig is the fruit of *Ficus Carica*. It consists of a succulent hollow receptacle, enclosing numerous single-seeded carpels (fig. 246), and is called a syconus (¶ 558). The fruit is demulcent and laxative, and is used for cataplasms. Many other species of *Ficus* yield edible fruits. The plants belonging to the Fig tribe are generally remarkable for the adventitious roots which they send out from the stems. One of the most celebrated in this respect is *Ficus indica*, the Banyan (¶ 121, 635). Many of the species can live suspended in the air for a long time. A specimen of *Ficus australis* has grown in this way in the Botanic Garden of Edinburgh for upwards of twenty years (¶ 217). *Ficus* (*Urostigma*) *religiosa* is the Pippul-tree, or Sacred Fig of India. *F. elastica* is an Indian tree which supplies a large quantity of caoutchouc; so also do *Ficus Radula*, *elliptica*, and *prinoides*. Peculiar clusters of raphides are found in the cellular tissue of some of them (fig. 39). The milky juice is not in all instances bland and innocuous; it occasionally has acrid qualities. *Ficus Sycomorus* (*Sycomorus antiquorum*), is probably the Sycamore of the Bible, the שִׁקְמִים (shikmim) of the Old Testament, and the *συκομορέα* of the New. The wood of the tree is said to be very durable. *Morus nigra* supplies the common black Mulberry, which is an anthocarpous fruit, composed of numerous succulent flowers, forming a sorosis (fig. 475). The Mulberry is the *συκάμινος*, or Sycamine-tree of the New Testament. Some have considered it as the שִׁקְמִים[*] of the Old Testament. The white Mulberry, a less esteemed fruit, is the produce of *Morus alba*. Both of these mulberries are subacid. Their leaves are the favourite food of silk-worms. The root of the white Mulberry is anthelmintic. *Dorstenias* have a slightly concave broad receptacle, bearing numerous flowers (fig. 245). *D. Contrayerva*, *D. Houstoni*, and *D. brasiliensis* furnish the Contrayerva-root of commerce. The officinal part is the root-stock, which is used as a stimulant, tonic, and diaphoretic. *Broussonetia papyrifera* is the Paper-mulberry, so called on account of being used in China and Japan in the manufacture of a kind of paper. It is called Crape-paper, and is prepared by pounding the bark, steeping it in water, then mixing it with glue, and taking it up with a mould of Bamboo-screen of the size required. The dye-wood called Fustic is the produce of *Maclura* (*Broussonetia*) *tinctoria*.

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[*] The בָּכָא of the Bible is the name of some tree or shrub (perhaps a Poplar), and it is doubtfully translated Mulberry-tree.

1022. The Artocarpus section is important as regards its uses. *Artocarpus incisa*, the Bread-fruit tree, supplies an amylaceous fruit, which furnishes an abundant supply of food in tropical countries. The properties of this tree are thus enumerated by Hooker:—The fruit serves for food; clothes are made from the fibres of the inner bark; the wood is used for building houses and making boats; the male catkins are employed as tinder; the leaves for table-cloths and for wrapping provisions in; and the viscid milky juice affords birdlime. *A. integrifolia* is the Jack or Jaca, the fruit of which attains a large size, sometimes weighing thirty pounds, and is inferior in quality to the Bread-fruit. In both instances the fruit is a sorosis, consisting of numerous flowers on a common axis, which becomes succulent. The milky juice of many of the Artocarpus tribe supplies caoutchouc, and in some instances it is used as a substitute for milk. This is the case with the juice of *Galactodendron utile* (perhaps a species of *Brosimum*,) which is called Palo de Vaca, or the Cow-tree, in Demerara. While the juice of some is nutritive, that of others is highly poisonous. Thus *Antiaris toxicaria* is the source of the famous poison called Bohun-Upas, or Upas-Antiar, by the Javanese, and which is said to owe its properties to the presence of Strychnia. Another Upas poison, called Upas-Tieuté, has already been noticed under the order Loganiaceæ, as being the produce of a species of Strychnos. The wood of *Piratinera guianensis* (probably a species of *Brosimum*) is called Snake-wood, or Letter-wood in Demerara, and is used for articles of furniture. Specimens sent by Dr. Campbell from Demerara have been beautifully manufactured in Scotland. The bark of *Antiaris saccidora*, a gigantic tree, having a trunk 18 feet in circumference at the base, is used for forming sacks. These bags are formed by separating the bark entire from the wood throughout the whole extent, with the exception of a small portion at one end. The wood is then removed from the interior, a part being left with the bark attached to form the bottom of the sack. The tree is common in the jungles near Coorg, and the sacks made from it are in general use among the villagers for carrying rice. The seeds of many of the Artocarpus tribe are eaten. *Brosimum Alicastrum* yields Bread-nuts, which, when boiled or roasted, are nutritious and agreeable articles of food. *Cecropia peltata* is the Trumpet-wood, so called on account of the hollowness of its stem and branches, which are used for wind instruments. The fibrous bark of the tree is used for cordage. By recent writers the suborders Urticeæ and Cannabineæ only are included in the order Urticaceæ. Ulmaceæ constitute an independent order, which has been subdivided into two suborders:—1. Celtideæ, Nettle-trees, with a 1-celled ovary and amphitropal ovules. 2. Ulmeæ, true Elms, with a 2-celled ovary and anatropal ovules. The plants of the Mulberry and Bread-fruit tribes have also been constituted into a separate order, under the title of Artocarpaceæ, which differs from the true Urticaceæ chiefly in being lactescent, and in their fruit being a sorosis or syconus.

1023. Order 167.—**Ceratophyllaceæ**, the Hornwort Family. (*Apet. Diclin.*) Flowers unisexual. Perianth inferior, 10-12-parted. Male flowers: stamens 12-20; anthers sessile, bilocular. Female flowers: ovary free, 1-celled; ovule solitary, pendulous, orthotropal; style filiform, oblique; stigma simple. Fruit a 1-celled indehiscent nut, terminated by the hardened style. Seed solitary, pendulous, exalbuminous; cotyledons 2, but apparently 4; radicle inferior.—Aquatic submersed herbs, with verticillate leaves cut into filiform lobes. They are found in ditches in various parts of Europe, Asia, and America. The affinities of the order are still obscure. Some authors consider it as allied to Lythraceæ, others to Chenopodiaceæ, while Lindley puts it in his Urtical alliance. Its properties are unimportant. There is only 1 genus, and about 6 species. *Example*—Ceratophyllum.

1024. Order 168.—**Podostemaceæ**, the Podostemon Family. (*Apet. Monoclin.*) Flowers naked, or with a more or less perfect perianth, bursting through an irregularly lacerated spatha. Stamens hypogynous, definite or indefinite, distinct or monadelphous; anthers dithecal, with longitudinal dehiscence. Ovary free, 2-3-celled; ovules numerous, anatropal, attached to a fleshy central placenta; styles or stigmas 2 or 3. Fruit slightly pedicellate, capsular, 2-3-valved. Seeds 00; embryo exalbuminous, orthotropal.—Herbaceous, branched, floating plants, with capillary, or linear, or lacerated, or minute and imbricated leaves. Natives chiefly of South America, and of the islands to the east of Africa. They flower and ripen seed under water, and furnish salt. The affinities of the order are uncertain. Some authors put it among the Monocotyledons. Genera 21, species 100. *Example*—Podostemon, Lacis.

1025. Order 169.—**Stilaginaceæ**, the Stilago Family. (*Apet. Diclin.*) Flowers unisexual. Perianth 2-3- or 5-partite. Male flowers: stamens 2 or more, arising from a swollen receptacle; filaments capillary; anthers innate, 2-lobed, with a fleshy connective, and vertical cells opening transversely. Female flowers: ovary free, 1-2-celled; ovules 2, anatropal; stigma sessile, 3-5-toothed. Fruit drupaceous. Seed solitary, suspended; embryo in fleshy albumen; cotyledons leafy; radicle superior.—Trees or shrubs, with alternate, stipulate leaves. Natives chiefly of the East Indies. Some yield edible fruits, others are used as potherbs. The position of this order in the natural system is obscure. Lindley places it in the Urtical alliance, others consider it as allied to Amentiferæ. There are 5 known genera, and about 22 species. *Examples*—Stilago, Antidesma.

1026. Order 170.—**Monimiaceæ,** the Monimia Family. (*Apet. Diclin.*) Flowers unisexual. Perianth somewhat globose, in one or more rows, divided at the border. Male flowers: stamens indefinite, covering the whole interior of the perianth; filaments often with 2 scales at the base; anthers dithecal, with longitudinal dehiscence. Female flowers: ovaries several, superior, enclosed within the tube of the perianth, each with 1 style and 1 stigma; ovule solitary, pendulous, anatropal. Fruit consisting of several achænia, enclosed within the enlarged perianth. Seeds pendulous; embryo at the end of copious fleshy albumen; radicle superior.—Trees or shrubs, with opposite exstipulate leaves. They are natives chiefly of South America and Australia. The bark and leaves are aromatic and fragrant. The succulent fruit of some is eaten. There are 8 known genera, and about 40 species. *Examples*—Monimia, Boldoa.

1027. Order 171.—**Atherospermaceæ,** the Plume-Nutmeg Family. (*Apet. Diclin.*) Flowers unisexual. Perianth tubular, divided at the top into several segments in 2 rows, the inner often petaloid, and accompanied in the female flowers with a few scales. Male flowers: stamens 00, inserted in the bottom of the perianth; filaments with scales at the base; anthers 2-celled, with valvular dehiscence. Female flowers: ovaries usually 00; ovule solitary, erect; style simple, lateral or basilar; stigmas simple. In some flowers, though rarely, stamens and pistils are found, and in that case the stamens are fewer, and arise from the orifice of the perianth. Fruit consisting of achænia, with persistent, ultimately feathery styles, enclosed within the tube of the perianth. Seed solitary, erect; embryo small, at the base of soft fleshy albumen; radicle inferior.—Trees, with opposite, exstipulate leaves, found in Australia, and in some parts of South America. They are generally fragrant. There are 3 known genera, and 4 species, according to Lindley. *Examples*—Atherosperma, Laurelia.

1028. Order 172.—**Lacistemaceæ,** the Lacistema Family. (*Apet. Diclin.*) Flowers polygamous. Perianth in several narrow divisions, covered by an enlarged bract. Stamen 1, hypogynous; anther having 2 cells, which are separated by a thick 2-lobed connective, and which dehisce transversely. Disk fleshy. Ovary superior, 1-celled; ovules several, anatropal, attached to 2-3 parietal placentas; stigmas 2-3, nearly sessile. Fruit a unilocular, 2-3-valved capsule, with loculicidal dehiscence. Seed usually, by abortion, solitary, suspended, with a fleshy arillus; spermoderm crustaceous; embryo in fleshy albumen; cotyledons flat; radicle cylindrical, superior.—Small trees or shrubs, with simple, alternate, exstipulate leaves, and amentaceous flowers.

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They are natives of the warm parts of America. Their properties are unknown. There are 2 genera, and 6 species. *Example*—Lacistema.

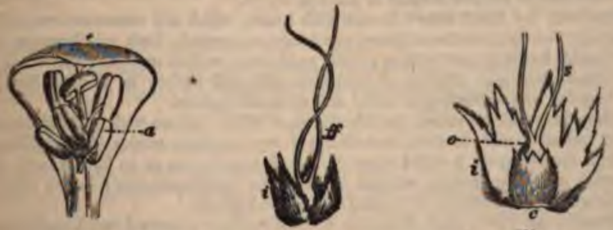
1029. Order 173.—**Chloranthaceæ,** the Chloranthus Family. (*Achlamyd. Monoclin.* or *Diclin.*) Flowers bisexual or unisexual, with a supporting scale. Perianth 0. Stamens definite, lateral, and if more than 1, connate; anthers monothecal, with longitudinal dehiscence, each adnate to a fleshy connective. Ovary unilocular; ovule solitary, pendulous, orthotropal; stigma sessile, simple. Fruit drupaceous, indehiscent. Seed pendulous; embryo minute, at the apex of fleshy albumen; cotyledons divaricate; radicle inferior, remote from the hilum.—Herbs or undershrubs, with jointed stems, opposite, simple, stipulate leaves, sheathing petioles, and spiked flowers. Natives of the warm regions of India and America. Some of them, as *Chloranthus officinalis*, are aromatic and fragrant, and have been used as stimulants and tonics. There are 4 known genera, and 16 species. *Example*—Chloranthus.

1030. Order 174.—**Saururaceæ,** the Lizard's-tail Family. (*Achlamyd.*) Flowers bisexual. Perianth 0, a scale or bract supporting the flowers. Stamens 3-6, clavate, hypogynous, persistent; filaments slender; anthers 2-celled, continuous with the filament, with a thick connective separating the lobes, dehiscence longitudinal. Ovaries 3-4, distinct, with 1 ascending orthotropal ovule, and a sessile recurved stigma, or united so as to form a 3-4-celled pistil, with several ovules and 3-4 stigmas. Fruit either consisting of 4 fleshy indehiscent nuts, or a 1-3-4-celled capsule, dehiscing at the apex, and containing a few ascending seeds. Seeds with a membranous spermoderm; embryo minute, lying in a fleshy vitellus, outside of hard mealy albumen at the apex of the seed.—Herbs growing in marshy places, with alternate, stipulate leaves, and spiked flowers. Natives of North America, India, and China. Their properties are said to be acrid. There are 4 known genera, according to Lindley, and 7 species. *Examples*—Saururus, Houttuynia.

1031. Order 175.—**Piperaceæ,** the Pepper Family. (*Achlamyd.*) Flowers ☿. Perianth 0, flowers supported on a bract. Stamens 2-3-6, arranged on one side or all round the ovary; anthers 1- or 2-celled, with or without a fleshy connective; pollen roundish, smooth. Ovary solitary, free, 1-celled; ovule solitary, erect, orthotropal; stigma simple, sessile, rather oblique. Fruit somewhat fleshy, indehiscent, unilocular. Seed erect; embryo in a fleshy vitellus outside the albumen, and at the apex of the seed.—Shrubs or herbs, with articulated stems, leaves opposite (sometimes alternate by abortion of one of the pair of leaves), or verticillate, exstipulate or stipulate, and spiked or racemose flowers. Natives of the hottest quarters of the globe. Common in South America and India. The wood is often arranged in wedges, with medullary rays, but without concentric zones. Their are 21 known genera, and upwards of 600 species. *Examples*—Piper, Artanthe, Peperomia.

1032. The plants of the order have pungent, acrid, and aromatic properties. Most of them contain an acrid resin, and a crystalline principle called Piperin, in which their active qualities reside. Some are narcotic and astringent. The dried fruiting spikes of *Piper longum*, an Indian creeper, constitute Long-pepper. Of late, however, the genus Piper has been subdivided, and this kind of pepper has been referred to various species of a new genus, *Chavica*, viz. *C. peepuloides*, *Roxburghii*, and *officinarum*. The dried unripe fruit (drupes) of *Piper nigrum* constitute Black-pepper, a climbing plant common in the East Indies. The ripe fruit, when deprived of its outer fleshy covering by washing, forms the White-pepper of the shops. These peppers are hot aromatic condiments, and they are used medicinally as tonic, stimulant, febrifuge, and stomachic. The fruit of *Piper Cubeba* (*Cubeba officinalis*), a climbing plant of Java and other Indian islands, is the medicinal Cubeb-pepper, which is used extensively in arresting discharges from mucous membranes. It contains a resin, a volatile oil which is very active, and a peculiar principle called Cubebin. The substance called Matico or Matica, consists of the leaves and unripe fruit of *Piper angustifolium* (*Artanthe elongata.*) It possesses aromatic, fragrant, and astringent qualities. It has been particularly recommended for checking hæmorrhage, a property which seems, in part, to be a mechanical one, depending on the structure of the leaf, which abounds in tannin. The root of *Macropiper methysticum* is the Kava of the South Sea Islanders, which is used by them for preparing a stimulating beverage. The leaf of Betel-pepper (*Chavica Betle*) is chewed with the Areca nut in the East, as a means of intoxication.

1033. Order 176.—**Amentiferæ**, the Catkin-bearing Family. (*Diclin.*) Flowers unisexual. Male flowers (fig. 721) capitate or in catkins



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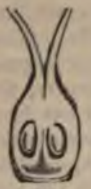
Figs. 721-727.—Organs of fructification of Corylus Avellana, the Hazel, to illustrate the natural order Amentiferæ, section Cupuliferæ.

Fig. 721.—Male flower separated from the catkin (amentum). *e*, Scale or bract bearing the stamens, *a*, with their dithecal anthers.

Fig. 722.—Female flower, *ff*, in a very young state, with its involucre, *i*.

Fig. 723.—Female flower more advanced. *i*, Involucre opened to show the ovary, *o*, covered by the perianth, *c*. *s*, Two styles.

(amenta), (fig. 238,) sometimes with a membranous perianth. Female flowers clustered, solitary (fig. 722), or in catkins. Stamens varying from 1 to 20, distinct (fig. 721) or monadelphous; anthers dithecal (fig. 721). Ovary usually simple (fig. 723 *o*); stigmas 1 or more (fig. 723 *s*). Fruit membranous or bony, or drupaceous, indehiscent (fig. 726), or dehiscent. Seeds solitary or numerous, erect or pendulous (fig. 724), usually exalbuminous; embryo straight or curved; radicle mostly superior (fig. 727).—Trees or shrubs, with alternate, stipulate, or exstipulate leaves. Natives chiefly of temperate climates. The order has been divided into the following suborders:—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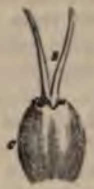

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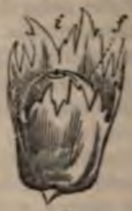

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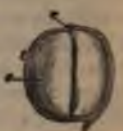
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1. Salicineæ, the Willow tribe: flowers naked, or with a membranous cup-like calyx; ovules 00, erect, anatropal; fruit naked, coriaceous, unilocular, 2-valved; seeds comose; embryo erect; radicle inferior; leaves stipulate. Found in woods in temperate and cold regions.
2. Myriceæ, the Gale tribe: achlamydeous flowers; stamens 2-8 in the axil of a scale, ovary 1-celled, with hypogynous scales; ovule solitary, erect, orthotropal; fruit drupaceous, often with a waxy secretion, and with fleshy adherent scales; radicle superior. Natives both of temperate and tropical regions, and found in North and South America, in India, and at the Cape of Good Hope.
3. Casuarineæ, the Beef-wood tribe: flowers with bracts; stamen 1; ovary 1-celled; ovules 1-2; fruit consisting of winged achænia, collected into a cone; seed erect; radicle superior. Australian trees or shrubs, with filiform branches, bearing membranous toothed sheaths in place of leaves.
4. Betulineæ, the Birch tribe: flowers with bracts, which are sometimes verticillate; ovary 2-celled; ovules solitary, pendulous, anatropal; fruit membranous, indehiscent, forming a sort of cone; seeds pendulous; radicle superior; leaves with deciduous stipules. Natives of temperate and cold regions in Europe, Asia, and America, and extending to arctic and antarctic regions.
5. Balsamifluæ (Altingiaceæ), the Liquidambar tribe: flowers with verticillate bracts or minute scales; anthers numerous; ovary 2-celled; ovules 00, amphitropal; fruit consisting of 2-celled capsules, united together so as to form a hard cone; seeds usually numerous, winged, albuminous; radicle superior; leaves stipulate. Balsamic trees, natives of tropical and warm regions.
6. Plataneæ, the Plane tribe: flowers in globose catkins; stamen 1, with scales; ovary 1-celled; style thick and subulate; ovules solitary or in pairs; suspended, ortho-

Fig. 724.—Female flower cut longitudinally, to show the two loculaments with a pendulous ovule in each.

Fig. 725.—Female flower more advanced. *c*, Perianth. *s*, Styles.

Fig. 726.—Ripe fruit, *f*, enveloped in its involucre or bracts, *i*.

Fig. 727.—Seed separated. *t*, Integument, half of which is removed to show the exalbuminous embryo, *e*. *r*, Superior radicle.

tropal; fruit consisting of compressed clavate nuts, terminated by a recurved style; seeds 1-2, pendulous, albuminous; radicle inferior; leaves palmate or toothed, and stipulate. Natives chiefly of temperate regions.

7. Cupuliferæ (Corylaceæ), the Nut tribe: flowers amentaceous (fig. 238) or aggregate; stamens 5-20, attached to scales (fig. 721) or a perianth; ovary surrounded by a coriaceous involucre (cupula), crowned by the remains of a persistent perianth (figs. 723, 725), multilocular; ovules 2 or 1, pendulous; fruit a glans (figs. 257, 726); seed usually solitary; radicle superior (fig. 727); leaves stipulate, often feather-veined (fig. 134). Natives of temperate regions chiefly. Some extend to warm countries.

This extensive Amental alliance, with which perhaps the next order should be incorporated, embraces 21 known genera, and 700 species. The suborders are by some considered as separate orders, and placed in various parts of their system of alliances. *Examples*—Salix, Populus; Myrica; Casuarina; Betula, Alnus; Liquidambar; Platanus; Corylus, Fagus, Castanea, Quercus.

1034. The Amentaceous order contains trees which yield valuable timber, and are extensively cultivated. Many have bitter, tonic, and astringent qualities. Some yield resinous and balsamic fluids; and the seeds of some are used as articles of food. The bark of many species of Willow, such as *Salix Capræa*, *alba*, *Russelliana*, *fragilis*, *pentandra*, *vitellina*, *purpurea*, and *Helix*, yields a neutral crystalline bitter substance called Salicin, which is employed as a febrifuge and tonic. The bark also possesses astringent qualities from the presence of tannin. Salicin assumes a carmine-red tint when moistened with a few drops of concentrated sulphuric acid. Various species of Willows (osiers) are used for basket-making, while others are employed in forming charcoal. *Salix babylonica* is the Weeping-willow. Its specific name is founded on the supposition, that it was the species on which the Israelites hanged their harps by the waters of Babylon. The word עֲרָבִים in the Bible is doubtfully translated Willow. *Populus alba* is commonly called the Abele, while *P. tremula* is the Aspen, and *P. fastigiata* and *dilatata* the Lombardy Poplar. The buds of *Populus nigra* and *balsamifera* are covered with a resinous exudation, to which the name of Tacamahac has been given; it is said to be diuretic and antiscorbutic. The leaves and bark of some Poplars secrete a saccharine substance, which has been termed Populine. *Salix arctica* and *polaris* extend to the arctic regions, and form the most northern woody plants. *Salix herbacea*, a small creeping Willow, occurs abundantly on the Scotch mountains. The downy matter surrounding the seeds of Poplars and Willows, is used for stuffing pillows and cushions, as well as for the manufacture of a kind of paper.

1035. The species of *Myrica* are aromatic, and yield resinous and oily matter. *Myrica Gale* is the Gale or Scotch Myrtle, which is common in marshy grounds and damp heaths in Britain. The fruit of *Myrica cerifera*, called Wax Myrtle, or Bay Myrtle, or Candleberry, yields a greenish-coloured wax, which is used for candles. The drupaceous fruit of some Myricas is eaten. The leaves of *Comptonia asplenifolia*, Sweet Fern, are found by Dr. Murchison to contain peculiar glands. Resinous matter is also procured from several species of *Liquidambar*, and is known by the name of Liquid Storax. *Liquidambar styraciflua*, *orientale*, and *Altingia*, are said to be the chief sources of this resin or balsam, containing Benzoic acid. The species of *Casuarina* (Cassowary-tree) yield excellent timber, called Beef-wood, from its having some resemblance to raw beef. What is called the She-oak in Australia, is *C. quadrivalvis*. In the integument of the seeds of *Casuarinas* there are numerous spiral cells.

1036. The species of *Betula*, Birch, have astringent and resinous barks. The oil from the bark of the common Birch (*Betula alba* and *glutinosa*) gives the peculiar odour to Russia leather. In North America the bark of the Canoe Birch (*Betula papyracea*) is used for making boats. A saccharine matter exists in the sap of the Birch. *Betula lenta* is the Black Birch of America, and is called Mountain Mahogany on account of the beauty and hardness of its timber. *Alnus glutinosa*, common Alder, grows well on the muddy ground on the banks of rivers. *Platanus orientalis*, the Oriental Plane, has broad palmate leaves, resembling the Sycamore, which is often erroneously called the Plane in Scotland. Some say that this is the Sycamore of the ancients. *Platanus occidentalis*, and *P. acerifolia*, are also cultivated as showy trees, under the name of Planes.

1037. The Hazel-nut, with its involucral appendage, is the produce of *Corylus Avellana*. The bark of *Quercus pedunculata* (*Robur*), the common Oak, contains much tannin, and is used as an astringent. Another British species, *Q. sessiliflora*, having sessile fruit, is said to yield the best timber. It is said that, in the wood of *Q. pedunculata*, there are numerous medullary rays (silver-grain), (fig. 99), while in that of *Q. sessiliflora*, Durmast, there are scarcely any visible. There is some doubt as to the existence of more than one species in Britain, and no permanent characters have been established. Babington mentions three species. It has been stated that 2000 well-grown oaks, equal to 3000 loads of timber, are required to build a seventy-four gun-ship. The acorns of *Quercus Ægilops*, Valonia or Balonia Oak, under the name of Velonia, are used by dyers. Oaks are liable to the attacks of insects, whose punctures give rise to the formation of galls. These excrescences occur on the buds, bark, and leaves. The medicinal galls are the produce of *Quercus infectoria*, a native of Asia Minor, and the best are imported from Aleppo. They are caused by punctures from the ovipositor of the Diplolepis (Cynips) Gallæ-tinctorum. Blue galls are those which still contain the young insect in their interior, while white galls are those from which it has escaped. In medicine they are employed as powerful astringents, and in the arts they are used for dyeing, tanning, and forming ink. The bark (Epiphlœum) of *Quercus Suber* constitutes cork (fig. 100). The bark of *Quercus tinctoria* is called Quercitron, and yields a yellow dye. *Quercus Ilex*, Evergreen Oak, is commonly cultivated in gardens. The Oak, אֵלָה of the Bible, is said by some to be *Quercus Grammuntia*. The Beech-tree (*Fagus sylvatica*), the Horn-beam (*Carpinus Betulus*), and the Spanish Chestnut (*Castanea vesca*), belong to the Cupuliferous section of this order. *Fagus Forsteri* is the Evergreen Beech of South America, found at Terra del Fuego. A species of Beech (*F. antarctica*) is found in the antarctic regions.

1038. Order 177.—**Juglandaceæ**, the Walnut Family. (*Apet. Diclin.*) Flowers unisexual. Male flowers amentaceous: perianth membranous, oblique, irregularly-lobed, with a scaly bract. Stamens definite or 00; filaments short, free; anthers dithecal, erect. Female flowers in terminal clusters, or in loose racemes, with separate or united bracts: perianth single or double, the outer 3-5-parted, inner, when present, in minute separate pieces. Ovary adherent to the perianth, 1-celled; ovule solitary, erect, orthotropal; styles 1-2, very short; stigmas 2-4, fringed or sessile, discoid and 4-lobed. Fruit a drupe, sometimes with an adherent involucre; endocarp bony, 2-valved or valveless, 2-4-celled at the base, and 1-celled at the apex, with partial dissepiments. Seed exalbuminous, 2-4-lobed, with a membranaceous testa; embryo large; cotyledons fleshy, oily and sinuous; radicle superior.—Trees with alternate, pinnated leaves, having neither dots nor stipules. They are chiefly natives of North America. There are 5 genera, according to authors, and 28 species. *Examples*—Juglans, Carya.

1039. While the plants belonging to this order yield edible oily nuts, their bark is often acrid, and there is frequently bitterness and astringency in the coverings of their fruit and seed. The seeds of *Juglans regia*, common Walnut, yield a bland oil, which may be used as a substitute for olive-oil. *Carya alba* yields the American Hickory-nut. Purgative and resinous properties prevail in some of the plants. The timber of many of the trees is valuable. That of the Black Walnut (*Juglans nigra*) has a fine dark-brown colour when polished.

1040. Order 178.—**Garryaceæ**, the Garrya Family. (*Apet. Diclin.*) Flowers unisexual, amentaceous. Male flowers: perianth of 4 parts. Stamens 4, alternate with the segments of the perianth. Female flowers: perianth superior, 2-toothed. Ovary unilocular; ovules 2, pendulous on short funiculi; styles 2. Fruit baccate, indehiscent. Seeds 2; embryo minute, at the base of fleshy albumen.—North American shrubs, with opposite, exstipulate leaves. The male plants of *Garrya elliptica* are commonly cultivated in shrubberies, and are prized for their peculiar silky catkins. Lindley associates with this order the Helwingiaceæ, which agree in their unisexual flowers, adherent fruit, pendulous ovules, minute embryo, at the base of solid albumen. Dr. Hooker refers Helwingia to Araliaceæ. There are 2 known genera, and 6 species. *Example*—Garrya.

5. SPOROGENÆ OR RHIZANTHÆ.

Having spore-like seeds with an Acotyledonous embryo.

1041. Order 179.—**Rhizantheæ,** the Rhizanth or Rhizogen Family. (*Apet. Diclin.*) Flowers usually monœcious or diœcious, sometimes ☿. Perianth more or less perfect, superior, trimerous, tetramerous or pentamerous, sometimes obsolete or 0. Stamens united, often in a fleshy column, to which the anthers cohere, dithecal, extrorse, opening longitudinally or by pores. Ovary inferior, 1-2-celled; ovules definite or 00. Fruit indehiscent, pulpy, usually unilocular. Seeds sometimes solitary and pendulous, at other times 00, and attached to parietal placentas; embryo albuminous or exalbuminous.—Leafless, scaly, parasitic plants, having a fungus-like appearance. They are never green, but assume a brown, yellow, or purple colour. They are composed chiefly of cellular tissue, with a few scalariform and spiral vessels. They are often stemless, and sometimes are furnished with a creeping rhizome. In their mode of decay they resemble Fungi. Their seeds present a peculiar appearance, resembling spores rather than true seeds. The nature of their embryo is undetermined, and their place in the natural system is still disputed. Lindley has placed them in a separate class, intermediate between Thallogens and Endogens. They have been divided by him into three distinct orders:—1. Balanophoraceæ, male flowers pedicellate; stamens 1-3; filaments and anthers both united; ovule solitary, pendulous; fruit monospermous. 2. Cytinaceæ, flowers in spikes; perianth 3-6-lobed; anthers sessile on a column, dehiscing by slits; ovules 00, attached to parietal placentas; fruit polyspermous. 3. Rafflesiaceæ, flowers sessile, solitary; perianth 5-lobed, with calli in its throat; anthers attached to a column, dehiscing by pores; ovules 00, attached to parietal placentas; fruit polyspermous. They are natives chiefly of tropical countries, but some extend into temperate climates. They are found in the East Indies, South America, Cape of Good Hope, and the south of Europe. Authors enumerate 26 genera, and 60 species. *Examples*—Balanophora, Cynomorium, Cytinus, Rafflesia.*

1042. Some of the plants are astringent, and have been employed as styptics. *Cynomorium coccineum*, commonly known as Fungus melitensis, grows in Malta, and was long celebrated for arresting hæmorrhage. *Cytinus* is parasitic on the roots of Cistuses in the south of Europe. *Cytinus hypocistis* is said to contain gallic acid. The species of *Rafflesia* are gigantic parasites, the perianth being sometimes three feet in diameter, and capable of holding twelve pints of fluid. They are parasitic on the stems of a species of Cissus, as well as on some leguminous plants. *R. Patma* is employed in Java as an astringent and styptic. Flower of *R. Arnoldi* sometimes weighs more than 14 lbs.

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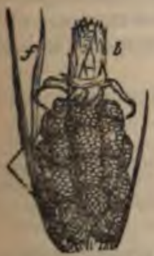
* Rafflesiaceæ are more properly placed near Aristolochiaceæ. Balanophoraceæ are epigynous Calycifloræ, and ought, according to Hooker, to be placed between Halorageaceæ and Gunnera.

Section B.—Gymnospermæ.*

1043. Monochlamydeous or Achlamydeous plants, with an Exogenous structure as regards their stems and organs of vegetation, but differing from Exogens in having naked ovules, which are fertilized by the direct application of the pollen to the foramen, without the intervention of stigma, style, and ovary. Their woody tissue is marked by the presence of disks (figs. 47, 48, 808). They are included in Lindley's class of Gymnogens, and Endlicher's Gymnospermous division of Acramphibrya.

1044. Order 180.—**Coniferæ**, the Cone-bearing Family. (*Achlamyd. Diclin.*) It includes the orders Pinaceæ, Taxaceæ, and Gnetaceæ of Lindley. Flowers unisexual. Male flowers monandrous or monadelphous: stamens collected in a deciduous amentum, about a common rachis (fig. 728); anthers 1-2 or many-lobed, with longitudinal dehiscence, often terminated by a scaly crest (fig. 729). Female flowers in cones (fig. 730), sometimes solitary: ovary none, its place being supplied by the flat scales of the cones, arising from the axil of membranous bracts (fig. 731); ovules naked, usually in pairs on the face of the scales (figs. 731, 732 *o o*), inverted or erect; style 0; stigma 0. Fruit a cone (figs. 201, 476, 477), or a solitary naked seed (fig. 442.) Seed



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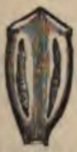
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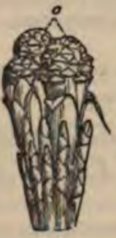

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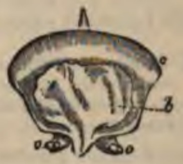

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* Γυμνὸς, naked, and σπέρμα, seed.

Figs. 728-734.—Organs of fructification of Pinus sylvestris, Scotch Fir, to illustrate the natural order Coniferæ.

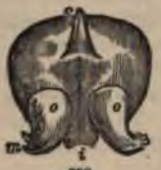
Fig. 728.—Collection of male catkins, *c*, clustered round a common axis. *f*, Leaves. *b*, Terminal buds, with young leaves and scaly sheaths.

Fig. 729.—Male flower, or the two-lobed anther, separated.

Fig. 730.—Three collections of female flowers, or young cones, *c*, at the extremity of a branch.

Fig. 731.—A scale detached from one of these young cones, and seen on the exterior. *b*, Bract. *c*, Scale. *o o*, Summit of the naked ovules.

with a hard crustaceous integument, sometimes winged (fig. 733); embryo in the midst of fleshy oily albumen (fig. 734); sometimes more than one embryo; cotyledons 2, or many and verticillate (fig. 734); radicle next the apex of the seed, organically connected with the albumen.—Trees or shrubs, with branched, usually resinous trunks, the wood marked with circular disks (figs. 47, 48, 808), the leaves usually narrow, rigid or acerose, entire (fig. 147), sometimes fascicled, and with a scaly sheath at their base (fig. 728 *b*). They are found in various parts of the world, both in cold and hot regions. They abound in the temperate regions of Europe and America, and many occur in Australasia. Four genera of Coniferæ, *Araucaria*, *Phyllocladus*, *Microcachrys*, and *Arthrotaxis*, are peculiar to the southern hemisphere. The following attain their maximum to the south of the tropics,—*Callitris*, *Podocarpus*, and *Dacrydium*. *Dammara* has one species in each hemisphere.



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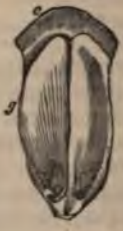

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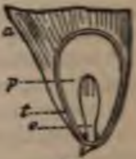

734

1045. The order is a very extensive one, and has been divided into the following suborders:—

1. Abietineæ, the Fir and Spruce tribe: fertile flowers in cones, with 1 or 2 inverted ovules at the base of each scale; embryo in the axis of fleshy and oily albumen, di- or poly-cotyledonous. Under this tribe are included the following sections and sub-sections:—
    - A. Scales 2-seeded, seeds adnate to the scale, and at length separating from it; anthers bilocular.
        - *a.* Scales with a thickened apophysis, which is either entire or dimidiate.
            - *Pinus.*—Leaves in twos, threes, fours, or fives.
        - *b.* Scales without an apophysis.

Fig. 732.—Scale of a young cone seen on the inside. *c*, The scale. *i*, The point by which it is attached to the axis of the cone. *o o*, The two naked inverted ovules. *m*, Their upper opening or foramen to which the pollen is applied. The foramen was formerly described erroneously as a stigma.

Fig. 733.—A scale from a mature cone. *c*, The scale. *i*, Point of insertion. *g*, One of the winged seeds; the other having been removed.

Fig. 734.—The seed cut longitudinally. *a*, Base of the wing. *t*, Integument. *p*, Perisperm (albumen). *e*, Polycotyledonous embryo. Near the radicle are the remains of two other abortive embryos.

* Leaves solitary.

Abies.—Scales deciduous, leaves flat.

Picea.—Scales persistent, leaves tetragonous.

Tsuga.—Scales persistent, leaves flat.

* * Leaves fasciculated.

Larix.—Leaves flat, annual.

Cedrus.—Leaves tetragonous, perennial.

B. Scales 1-seeded, seed adnate to the scale, and not separating from it, anthers multilocular.

Araucaria (*Eutassa* and *Altingia*).

C. Scales 1- or many-seeded, seeds free, anthers bi- tri- or multi-locular.

Dammara.—Anthers multilocular.

Cunninghamia.—Anthers trilocular.

Arthrotaxis.—Anthers bilocular.

2. Cupressineæ, the Cypress tribe: ovules erect; fruit an indurated cone (fig. 477), or fleshy, with the scales connected, forming a galbulus (fig. 478); embryo di- or poly-cotyledonous. *Examples*—Cupressus, Juniperus, Thuja, Taxodium, Cryptomeria, Callitris.

3. Taxineæ, the Yew tribe: anthers usually bilocular, with longitudinal dehiscence: fertile flowers, solitary, terminal; ovule solitary, sessile in the centre of a fleshy disk, when in fruit forming a sort of drupe (fig. 442); embryo dicotyledonous. *Examples*—Taxus, Podocarpus, Dacrydium, Phyllocladus, Salisburia.

4. Gnetaceæ, the Joint-fir tribe: male flowers with a perianth, anthers uni- or quadrilocular, opening by a short cleft; ovules with a projecting process formed from the intimate covering of the nucleus; seed solitary; embryo with a long spirally-twisted funiculus; stems jointed; zones of wood, often separated by marked cellular circles (fig. 104). *Examples*—Gnetum, Ephedra.

The order embraces 40 known genera, and 182 species, according to authors. Zuccarini enumerates 208 species of Coniferæ,—in the northern hemisphere, 165, and in the southern, 51; some species being common to both hemispheres.

1046. The plants of this order furnish valuable timber, and yield various important products, such as turpentine, pitch, and resin. The various kinds of Pine, Fir, Spruce, and Cedar, belong to this family. *Eutassa* (*Araucaria*) *excelsa* is the Norfolk-island Pine, famed for its size and for its wood. *Cedrus Libani* is the Cedar of Lebanon, the ארז of the Bible, while *Cedrus Deodara* is the Deodar or Himalayan Cedar. By exudation, and partly by the aid of heat, the plants of this order yield various kinds of turpentine, resin, tar, and pitch. Common turpentine is procured from *Pinus sylvestris*, the Scotch Fir, *Pinus Pinaster*, the Cluster-Pine, and var. *maritima*, Bourdeaux Pine, *Pinus palustris*, Swamp Pine, and *Pinus Tæda*, Frankincense Pine. Oil of turpentine is obtained from it by distillation. Venice turpentine and Strasburg turpentine are the produce of *Abies Picea* (*Abies* or *Picea pectinata*), the Silver Fir, and *Larix europæa*, the Larch; while

Canada Balsam is collected from *Abies* or *Picea balsamea*, Balm of Gilead Fir, and *A. canadensis*, Hemlock Spruce. *Dammara australis*, the Kawrie-tree of New Zealand, yields a hard resin, and so does *D. orientalis*, the Amboyna Pitch-tree. *Callitris quadrivalvis* (*Thuja articulata*), the Arar-tree, supplies a solid resin called Sandarach or Pounce, which is used to strew over manuscripts. Thus, or Common Frankincense, and Burgundy-pitch, are yielded by *Abies excelsa*, Norway Spruce Fir. *Pinus Pumilio* gives Hungarian balsam, *Pinus pinea*, the Stone Pine, is the source of Carpathian balsam. Essence of Spruce, used in making Spruce-beer, is got by boiling in water the leaves of the Scotch Fir (*Pinus sylvestris*), the Black Spruce (*Abies nigra*), and other species. A kind of Manna is procured from the Larch and from the Cedar of Lebanon. The Bark-bread of the Norwegians is prepared from the inner bark of *Pinus sylvestris*. These various kinds of resin and pitch are used for stimulating and healing plasters, while the oil of turpentine (*oleum terebinthinæ*) is employed medicinally as a stimulant, diuretic, cathartic, and anthelmintic. The vapour of tar has been recommended in affections of the chest. The succulent cones (fig. 478) (commonly called berries) of *Juniperus communis*, Common Juniper, and the oil procured from them, are used medicinally as diuretics. The oil enters into the composition of the spirituous liquor called Hollands. The young branches and leaves of *Juniperus Sabina*, Savin, contain an active volatile oil, which is used as an anthelmintic and emmenagogue. In large doses it acts as a violent irritant poison. The wood of *Juniperus Bermudiana* furnishes Pencil Cedar. *J. Virginiana*, the Red Cedar, yields a rubefacient oil. *Thuja occidentalis* is the common Arbor-vitæ of gardens. *Thuja orientalis* is also in cultivation. *Cupressus sempervirens*, common Cypress, yields a durable wood, which is supposed to be the Gopher-wood, גפר of the Bible. *Podocarpus Totarra* and *Dacrydium taxifolium*, both supply good timber in New Zealand. *Taxus baccata*, the Yew, is a valuable timber tree. It yields resin, and its leaves and seeds are said to be narcotico-acrid. *Salisburia* has remarkable cuneate leaves, and the fruit of *S. adiantifolia*, the Ginko, is said to be eatable. *Gnetum urens* has singular stinging hairs within the episperm or outer integument of the seed.

1047. Order 181.—**Cycadaceæ**, the Cycas Family. (*Achlamyd. Diclin.*) Flowers unisexual. Males collected into cones, the scales bearing on their lower surface 1-celled anthers, which are united often in sets of two, three, or four. Females consisting of naked ovules, placed at the base of flat scales, or beneath peltate ones, or seated on the margins of altered leaves. Seeds hard and nut-like, sometimes with an external spongy coat; embryos 1 or 2, suspended in a central cavity; albumen fleshy or mealy; cotyledons unequal; dicle superior, having a long cord-like prolongation by which the embryo is suspended.—Trees or shrubs, with cylindrical trunks, usually simple, sometimes dichotomous, marked with the scars of the leaves, and in many respects having the aspect of Palms (fig. 817). The internal structure is more or less distinctly that of dicotyledons. Pitted tissue and spiral vessels occur. The leaves are pinnate, and their vernation is circinate, thus resembling ferns. The plants of this order are found in the temperate and warm regions of America and Asia, as well as at the Cape of Good Hope. There are 7 genera, according to authors, and 50 species. *Examples*—Cycas (fig. 817), Zamia (fig. 818). Dion, Encephalartos, Macrozamia.

1048. The Cycadaceous family yields much starchy matter, along with mucilage. From the stems of *Cycas revoluta* and *circinalis*, a kind of Sago is made. A clear insipid mucilage also exudes from them, which hardens into a transparent gum resembling tragacanth. *Dion edule* yields a kind of arrow-root in Mexico. *Zamia pumila*, and other species in the West Indies, supply an amylaceous matter which has been sold as Arrow-root. The Bread-tree is a name applied by the Hottentots to various species of *Encephalartos*.

CLASS II.—MONOCOTYLEDONES, *Juss.* ENDOGENÆ, *DC.* ENDOGENS AND DICTYOGENS, *Lindl.* AMPHIBRYA, *Endl.*

1049. In this great class the plants have a *cellular* and *vascular* system, the latter consisting partly of elastic spiral vessels (fig. 51). The woody *stem* (as in Palms, fig. 115, 1) is usually more or less cylindrical, simple, and unbranched. There is no true separable bark, no concentric zones, and no true pith (figs. 112, 113). The *wood* is endogenous, *i.e.* increases by additions, which first tend towards the centre, and then curve outwards in an interlacing manner (fig. 114, 2) towards the circumference, where much hard ligneous matter is deposited, so as to make the exterior the hardest part (figs. 826, 827). The development of the stem usually takes place by a single central and terminal bud; occasionally lateral buds are produced (fig. 115, 2), and at times the stem is hollow. The *leaves* are parallel-veined (figs. 135, 173, 194), except in the subclass Dictyogens, where a kind of reticulation is visible. The parts of the *flower* are arranged in a ternary manner (fig. 538), and they are often petaloid (fig. 260), sometimes scaly or glumaceous. The ovules are contained in an ovary, and are fertilized by the application of the pollen to the stigma. The *embryo* has one cotyledon (fig. 504), and the germination is endorhizal (fig. 527).

Subclass 1.—DICTYOGENÆ.[*]

1050. Leaves reticulated, often articulated with the stem, branches having the usual structure of Endogens, rhizomes or underground stems having the woody matter disposed in a compact circle, or in wedges containing central cellular tissue, and often showing medullary processes.

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[*] Δίκτυον, a net, and γεννάειν, to produce.

1051. Order 182.—**Dioscoreaceæ**, the Yam tribe. (*Mono-epigyn.*) Flowers unisexual. Perianth in 6 divisions, adherent. ♂. Stamens 6, inserted into the base of the perianth; anthers introrse, with longitudinal dehiscence. ♀. Ovary inferior, 3-celled; ovules 1-2, anatropal; style bifid; stigmas undivided. Fruit a compressed trilocular capsule, with 2 cells, sometimes abortive, occasionally fleshy and indehiscent. Seeds compressed, winged or wingless, in the succulent fruit, ovate; embryo small, near the hilum, lying in a large cavity of cartilaginous albumen.—Twining shrubs, with large epigeal or hypogeal tubers, alternate, sometimes opposite, reticulated leaves, and small, spiked, bracteated flowers. Natives chiefly of tropical countries; a few only found in temperate regions. There are 8 genera, according to authors, and 150 species. *Examples*—Dioscorea, Tamus.

1052. Although farinaceous matter exists in the tubers of many species, yet there is a prevalent acridity throughout the order. Various species of *Dioscorea*, as *D. alata*, *sativa*, and *aculeata* produce the tubers called Yams, which are used in warm countries as a substitute for the potato. *Testudinaria Elephantipes* is the Tortoise plant of the Cape, or Elephant's-foot, so called on account of its peculiar shortened and thickened stem (¶ 92). *Tamus communis*, Black Bryony, is common in hedges in England. It produces red succulent fruit, and has a large root, which is acrid. This acridity does not extend to the young suckers, which may be eaten with impunity. The acridity of the order sometimes manifests itself in purgative qualities.

1053. Order 183.—**Smilaceæ**, the Sarsaparilla Family. (*Mono-perigyn.*) Flowers bisexual or polygamous. Perianth petaloid, 6-parted. Stamens 6, inserted into the base of the perianth, rarely hypogynous. Ovary free, 3-celled; cells uni- or multi-ovulate; ovules orthotropal; styles usually 3-cleft; stigmas 3. Fruit globular and succulent. Seeds with fleshy, cartilaginous albumen; embryo very small; usually distant from the hilum.—Herbs or undershrubs, often climbing, with netted-veined leaves. Natives of the temperate and tropical regions of Asia and America. There are 6 known genera, and upwards of 120 species. *Examples*—Smilax, Philesia.

1054. Mucilaginous and demulcent properties prevail throughout the order. The root of various species of *Smilax* constitutes the Sarsaparilla or Sarza of the pharmacopœias. Linnæus considered *Smilax Sarsaparilla*, a native of the United States, as the plant which furnished Sarsaparilla, but recent observers state that this is not the case. The following are enumerated as sources whence Sarsaparilla of various kinds is derived.

1. Smilax officinalis, found in woods near the Rio Magdalena in Columbia. It furnishes Jamaica Sarza, which is the best in the market.
2. Smilax medica, native of the Mexican Andes. It is thought to furnish Vera Cruz Sarza.
3. Smilax syphilitica, found in Brazilian Guiana. It in part supplies Brazil and Lisbon Sarza.
4. Smilax cordato-ovata, a Brazilian species. Brazil Sarza in part.
5. Smilax papyracea, a Brazilian species. Brazil and Lisbon Sarza in part.
6. Smilax Brasiliensis, a Brazilian species. Brazil Sarza.
7. Smilax, sp.? from Angostura, supplies Rio Negro Sarza.
8. Smilax, sp.? from Honduras, supplies Honduras Sarza.

Mr. H. Scott says that the source of Red Sarza is *S. paraguensis*, which includes *S. papyracea*, *Brasiliensis*, and *officinalis*. Besides these species, there are others which furnish substitutes, viz:—

9. Smilax Purhampuy, a Peruvian species.
10. Smilax excelsa and aspera, are used as substitutes in Europe.
11. Smilax Zeylanica, glabra, perfoliata, and leucophylla, in Asia.
12. Smilax China, a Chinese plant yielding China-root.
13. Smilax Pseudo-China, from the United States.

The officinal part is the roots which come off from the rhizomes. The roots are mucilaginous, bitterish, and slightly acrid. They contain mucilage, starch, oil, resin, and a crystalline principle called Pariglin or Smilacin. Sarsaparilla is used in decoction and infusion, as a tonic and alterative, in cachectic and syphilitic cases.

1055. Order 184.—**Trilliaceæ**, the Trillium Family. (*Mono-perigyn.*) Flowers usually bisexual. Perianth in 6, sometimes 8 divisions, coloured or herbaceous. Stamens 6, 8, or 10; filaments subulate; anthers linear, with a prolonged connective. Ovary free, 3- 4- or 5-celled; styles as many, distinct; ovules 00, anatropal. Fruit succulent, 3- 4- or 5-celled. Seeds 00; embryo minute, in fleshy albumen.—Natives of the temperate parts of Europe, Asia, and America. Some of them are more or less acrid, others are narcotic. The rhizome of *Trillium cernuum* is used as an emetic. The juice of the berries mixed with alum gives a blue colouring matter. *Paris quadrifolia*, Herb Paris, is narcotic. There are about 10 known genera, and upwards of 60 species. *Examples*—Trillium, Paris, Triuris?

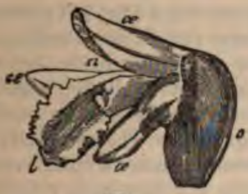
Subclass 2.—PETALOIDEÆ.

1056. Flowers having usually a perianth consisting either of verticillate leaves, which may sometimes be separated into calyx and corolla, and are often coloured (petaloid), or of a few whorled scales. Occasionally the perianth is abortive.

a. Perianth adherent, Ovary inferior, Flowers usually hermaphrodite.

1057. Order 185.—**Hydrocharidaceæ**, the Frog-bit Family. (*Mono-epigyn.*) Flowers spathaceous, unisexual, rarely ☿. Perianth with a 6-partite limb, the 3 outer segments herbaceous, and equivalent to the calyx, the 3 inner petaloid, and equivalent to the corolla. Stamens definite or indefinite, epigynous. Ovary adherent, 1 or many-celled; ovules 00, anatropal, frequently attached to parietal placentas; stigmas 3-6. Fruit dry or succulent, indehiscent, uni- or multilocular. Seeds numerous, exalbuminous; embryo straight, radicle remote from the hilum.—Floating or aquatic plants, with parallel-veined leaves, sometimes spiny. Chiefly found in Europe, Asia, and North America. The plants of this order are not remarkable for their properties. Some are mucilaginous and astringent. *Vallisneria spiralis* (fig. 228) is a diœcious plant, the male flowers of which, at the time of flowering, are said to be detached from the mud of the water in which they grow, and to float on the surface. At the same time the female flower develops a long spiral peduncle, by means of which it reaches the surface of the water, so as to allow the application of the pollen (¶ 496). The order has been divided into two sections:—1. Vallisnerieæ, ovary 1-celled. 2. Stratioteæ, ovary many-celled. There are 18 known genera, according to authors, including 24 species. *Examples*—Vallisneria, Udora, Anacharis, Stratiotes, Hydrocharis.

1058. Order 186.—**Orchidaceæ**, the Orchis Family. (*Mono-epigyn.*) Flowers bisexual. Perianth adherent, herbaceous, or coloured, with a 6-partite limb (fig. 736 *pe*, *pi*), the segments being arranged in 2 rows; exterior row (fig. 735 *ce*), called the calyx (although Lindley says it is more properly the corolla, the true calyx or calyculus being usually abortive), consisting of 3 segments (rarely 2 by adhesion), the odd one of which is often next the axis by a twisting of the ovary; interior row (fig. 735 *ci*), called the corolla (regarded by Lindley as petaloid stamens), consisting usually of 3 segments (very rarely 1), the odd one of which is called the labellum or lip. This labellum (figs. 735, 736, 737 *l*) frequently differs from the other divisions of the perianth, assuming remarkable forms, being lobed, spurred at the base, or furnished with peculiar appendages, which are sometimes derived from the stigma. It is sometimes divided by contraction, so as to exhibit three distinct portions, the lowest being the hypochilium (ὑπό, under, and χεῖλος, lip); the middle, mesochilium (μέσος, middle); and the upper, the epichilium (ἐπὶ, upon or above). Stamens 3, epigynous, united in a central column along with the style; the two lateral stamens are usually abortive (figs 736 *s s*), the central one opposite the odd exterior segment being fertile (fig. 736 *e*); but at times the two lateral are fertile, and the central one is abortive; anthers 1-2-4-celled (fig. 738); pollen powdery or cohering in definite (fig. 744) or indefinite waxy masses (pollinia) (figs. 739, 743), which often adhere by a caudicle (fig. 743 *c*) to a gland connected with the beak (rostellum) of the stigma. This gland is sometimes naked, at other times in a sac or pouch (bursicula). Ovary adherent, 1-celled (fig. 740), composed of 6 carpels, of which 3 only are placentiferous (Lindley); style incorporated with the column (gynostemium, γυνή, pistil, and στήμων, stamen); stigmas a viscid hollow space in front of the column (fig. 737 *s*),



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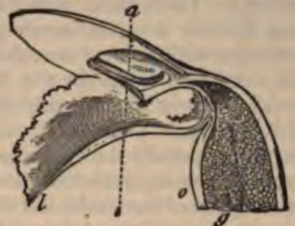

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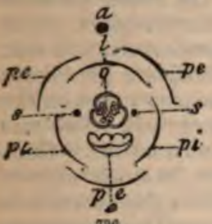

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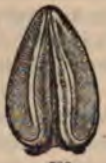

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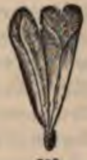

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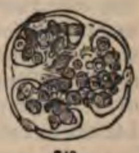

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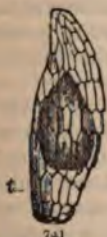

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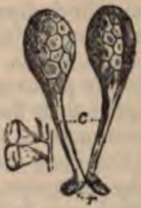


744 743

Figs. 735-741.—Flower of Spiranthes autumnalis, to illustrate the natural order Orchidaceæ.

Fig. 735.—Flower after the ovary has twisted on itself, seen laterally. *o*, Ovary with the adherent perianth. *c e*, Outer divisions of the perianth, called by some calyx, and by Lindley corolla. *c i*, Inner divisions of the perianth, called by some the corolla, and considered by Lindley as petaloid stamens. *l*, The labellum or lip, being the lower of the three inner segments.

Fig. 736.—Diagram of the flower in the young state, before the twisting of the ovary has taken place. *a*, The axis of the spike of flowers. *pe*, *pe*, *pe*, Outer perianth. *pi*, *pi*, Two divisions of the inner perianth. *l*, Third division of the inner perianth, in this state placed next the axis. *e*, Fertile anther. *s s*, Two abortive anthers or staminodia. *o*, Ovary.

Fig. 737.—Summit of the flower cut vertically. *o*, Adherent ovary with parietal ovules, *g*. *l*, Labellum or lip. *s*, Stigma. *a*, Anther.

Fig. 738.—Anther separated. Its inner surface shown with its two cells.

Fig. 739.—Granular pollen-masses taken from the anther.

Fig. 740.—Horizontal section of the ovary, with three parietal placentas bearing numerous ovules.

Fig. 741.—A seed separated, with its external reticulated integument, *t*.

Fig. 742.—Embryo of Aceras anthropophora deprived of its integuments.

Fig. 743.—Pollen-masses (Pollinia) of Orchis maculata, with the grains united in little conical masses. *c*, Caudicle terminated by the retinaculum and glands.

Fig. 744.—The conical masses which the pollen-grains form by their cohesion.

communicating directly with the ovary by an open canal. The upper part of the united stigmas is often extended into a beak-like process (rostellum). Placentas 3, parietal (figs. 457, 740). Fruit a capsule, opening by 3 or 6 valves, rarely fleshy, and indehiscent. Seeds 00, very minute, with a loose reticulated spermoderm (fig. 741), exalbuminous; embryo solid, fleshy (fig. 742); large radicle next the hilum.—Perennial herbs or shrubs, with fibrous or tubercular roots (fig. 121), either no stem or a pseudo-bulb, entire parallel-veined often sheathing leaves, and generally showy, attractive flowers. Sometimes buds are produced on the margins of the leaves (fig. 214). They are natives of almost all parts of the world, but they abound in moist tropical regions. They are not found in the arctic regions, nor in very dry climates. Some are terrestrial, and others are epiphytic. The former are commonly seen in temperate climates, the latter in warm regions. *Disa grandiflora* is found on Table Mountain at an elevation of 3,582 feet. The only known locality for it is in a marshy hollow, near the eastern extremity of the summit, where it is abundant among rushes on the margins of small pools and streamlets in a black boggy soil. Two rare species of Disa are also seen there, *D. ferruginea* and *tenuifolia*. *Oncidium nubigenum* is found on the Andes, near Quito, at an elevation of 14,000 feet above the level of the sea. *Epidendrum frigidum* occurs in Columbia at an elevation of 12,000 to 13,000 feet (mean temperature 46°), and is covered with a sort of varnish. Authors enumerate 494 genera, including above 3000 species; of these, 16 genera and 40 species are British. *Examples*—Stelis, Liparis, Dendrobium, Epidendrum, Vanda, Orchis, Ophrys, Arethusa, Neottia.

1059. The plants of this order are well distinguished by the peculiar forms of their flowers, their remarkable lip, gynandrous stamens, and pollen-masses. Their flowers often resemble insects, as butterflies, moths, bees, flies, and spiders; or birds, as doves and eagles; or reptiles, as snakes, lizards, and frogs. The colours and spots on the perianth sometimes give the appearance of the skins of quadrupeds, as the leopard and tiger. These resemblances are often indicated in the generic and specific names. The labellum, in some instances, displays peculiar irritability (¶ 665).

1060. Mucilaginous properties occur in many of the plants of this order. Some are aromatic and fragrant; others are antispasmodic and tonic. The tuberous roots of some yield a nutritious substance called Salep, which consists chiefly of bassorin, some soluble gum, and a little starch. The orchid yielding it is not well known; some say that it is *Orchis mascula*, others *O. papilionacea*, *Morio* and *militaris*, others *Eulophia vera* and *campestris*. Salep forms an article of diet fitted for convalescents, when boiled with water or milk. The roots of *Aplectrum hyemale* contain a very glutinous matter, and hence the plant is called in America Putty-wort. The fleshy pod-like fruit of

Vanilla planifolia, and *V. aromatica*, constitutes the substance called Vanilla, which is used in confectionery, and in flavouring chocolate. It contains an oil and much benzoic acid. A kind of Vanille called Chica in Panama is procured from a species of *Sobralia*. A blue colouring matter has been found in some of the orchids. The odour of many of them is very fragrant; sometimes it is oppressive; at other times, as in *Malachadenia clavata*, it is very fetid, resembling carrion.

1061. Order 187.—**Zingiberaceæ**, or **Scitamineæ**, the Ginger Family. (*Mono-epigyn.*) Perianth superior, in 2 whorls; outer (calyx) tubular, 3-lobed, short; inner (corolla) tubular, elongated, 3-parted, segments nearly equal. Stamens in 2 whorls; outer sterile, petaloid, having the appearance of a 3-parted corolline whorl, with the intermediate segment (labellum) larger than the rest, and often 3-lobed, sometimes the lateral segments are inconspicuous or nearly abortive; inner stamens 3, the two lateral being abortive, the intermediate one opposite the labellum, fertile; filament not petaloid, often prolonged beyond the anther; anther 2-celled, dehiscing longitudinally. Ovary 3-celled, or imperfectly so; ovules several, anatropal, attached to a placenta in the axis; style filiform; stigma dilated, hollow. Fruit usually a 3-celled capsule, sometimes baccate. Seeds roundish or angular, sometimes with an arillus; embryo enclosed in a vitellus (the remains of the embryo-sac), surrounded by farinaceous albumen, which is deficient near the hilum.—Herbs with a creeping rhizome, and simple sheathing leaves, having parallel veins proceeding from the midrib to the margin. The flowers arise from membranous spathaceous bracts. Natives of tropical countries. By far the greater number inhabit various parts of the East Indies; some are found in Africa, and a few in America. They form a part of the singular Flora of Japan. Authors mention 31 genera, and 250 species. *Examples* —Zingiber, Curcuma, Amomum, Hedychium, Renealmia.

1062. Plants often with showy flowers, having aromatic stimulant properties, which reside chiefly in their rhizome or root, and in their seeds. Some yield starchy matter. The rhizome of *Zingiber officinale* (*Amomum Zingiber*), constitutes the Ginger of commerce, which is imported from the East and West Indies. In the young state the rhizomes are fleshy and slightly aromatic, and they are then used as preserves; while in a more advanced state, the aroma is fully developed, their texture is more woody, and they are then fit for ordinary ginger. When dried, after immersion in hot water, they form Black ginger; when simply dried in the sun, after being cleaned, they receive the name of White ginger. The rhizome contains an acrid resin and volatile oil, starch and gum. It is used as a tonic and carminative, in the form of powder, syrup, and tincture. *Curcuma longa*, a native of Eastern Asia, furnishes Turmeric. This consists of the branches of the rhizome, or root-stock. Its powder is lemon-yellow, and it is used as a dyestuff. It contains starch, an acrid volatile oil, and a yellow colouring matter called Curcumin. It is employed medicinally as an aromatic carminative, and, as a condiment, it enters into the composition of curry-powder. The root-stocks of *Alpinia racemosa*, and *A. Galanga*, Galangale, and many other plants of the order, have the same properties as ginger. They have been used by the Indian doctors in cases of dyspepsia and in the treatment of coughs. Various species of *Amomum*, *Elettaria*, and *Renealmia*, appear to furnish the Cardamoms of the shops, which consist of the oval trivalvular capsules containing the seeds. The following are some of the sources whence Cardamoms are procured :—

1. Amomum Cardamomum, a Java plant, supplies the round Cardamoms.
2. A. angustifolium furnishes the large Madagascar Cardamoms, and also supplies some of the seeds called Grains of Paradise.
3. A. maximum produces the Java Cardamoms of the London market.
4. A. repens (Renealmia or Elettaria Cardamomum) is the source of Malabar Cardamoms.
5. Elettaria major is said to yield Ceylon Cardamoms.

The seeds of these plants are used as aromatic tonics and carminatives. Their active ingredient is a pungent volatile oil. Grains of Paradise are the seeds of *Amomum Melegueta*, Melegueta Pepper, and have the same properties as Cardamoms. East Indian Arrow-root is procured in part from *Curcuma angustifolia*, and a similar kind of starch is yielded by *Curcuma Zerumbet*, *C. leucorhiza*, and *Alpinia Galanga*.

1063. Order 188.—**Marantaceæ** or **Cannaceæ**, the Arrow-root Family. (*Mono-epigyn.*) Perianth superior, in 2 whorls; outer (calyx) 3-lobed, short; inner (corolla) tubular, elongated, 3-parted, segments nearly equal. Stamens in 2 whorls; outer sterile, petaloid, irregular, resembling a tubular trifid corolla, with one of the lateral segments different from the others; inner petaloid, 2 sterile, and 1 lateral fertile; filament of the latter petaloid, entire, or 2-lobed; anther on the margin of the filament, 1-celled, dehiscing longitudinally. Ovary 3-celled, rarely 1-celled; ovules solitary and erect, or numerous and attached to the axis; style petaloid or swollen; stigma either the naked apex of the style, or hollow, hooded, and incurved. Fruit a 3-celled capsule, or baccate, 1-celled and 1-seeded. Seeds round, without arillus; embryo straight, in hard, somewhat floury albumen, without a vitellus; radicle lying against the hilum (fig. 527).—Herbaceous plants, with tuberous rhizomes, and leaves and flowers, similar to those of the Ginger Family. They are natives of tropical America, and Africa; several are found in India; none are known in a wild state beyond the tropics. Authors enumerate 9 genera, including 164 species. *Examples*—Maranta, Canna, Phrynium.

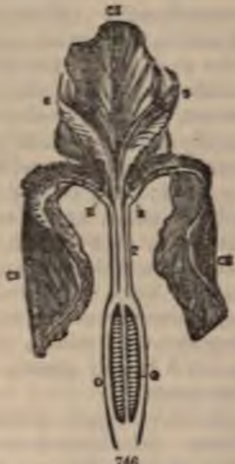
1064. The plants of the order contain much starch in the rhizomes and roots. They are destitute of aroma. Arrow-root is the produce of the tuberous rhizomata of *Maranta arundinacea* and *M. indica.* The best West Indian arrow-root comes from Bermuda. Its globules are much smaller and less glistening than those of tous-les-mois or potato starch. Amylaceous matter of a similar kind is produced from other species of *Maranta*, as well as from species of *Canna.* Tous-les-mois is the produce of *Canna coccinea, C. Achiras, C. edulis,* &c. The seeds of Cannas are round and black, and are commonly known under the name of Indian shot. They have been used as a substitute for coffee. *Calathea zebrina*, Zebra plant, is so called from the peculiar variegation of its leaves, which have a velvety aspect. Barnéoud states that the two outer verticils of the flowers in *Cannas* are always developed, one after the other, precisely like the calyx and corolla; while the verticil, sometimes called petals, is really metamorphosed stamens, and hence its irregular aspect.

1065. Order 189.—**Musaceæ**, the Banana Family. (*Mono-epigyn.*) Perianth 6-cleft, adherent, petaloid, in 2 whorls, more or less irregular. Stamens 6, inserted on the middle of the segments of the perianth, some usually abortive; anthers linear, dithecal, introrse, often with a membranous petaloid crest. Ovary inferior, 3-celled; ovules numerous, anatropal; style simple; stigma usually 3-lobed. Fruit either a 3-celled capsule, with loculicidal dehiscence, or succulent and indehiscent. Seeds sometimes surrounded by hairs; testa usually crustaceous; embryo erect, in the axis of mealy albumen; radicle touching the hilum.—Plants without true aerial stems, or nearly so, having shoots proceeding from subterranean root-stocks, which form spurious stems, composed of the sheathing leaf-stalks. Veins in the limb of the leaf parallel, and proceeding in a curved manner from the midrib to the margin (fig. 135). Flowers bursting through spathas. Natives of warm and tropical regions. There are 5 known genera, and 21 species. *Examples*—Musa, Strelitzia, Ravenala.

1066. The plants of this order furnish a large supply of nutritious fruit, and their leaves afford valuable fibres. Spiral vessels abound in them. *Musa sapientum* and *Cavendishii* furnish different kinds of Banana, while *M. paradisiaca* yields the Plantain. These fruits in their ripe state contain much starchy matter. From their spurious stems, the fibres of the spiral vessels may be pulled out in such quantity as to be used for tinder. The ribbon-like fibre in these vessels is composed of several threads united together (pleiotracheæ) (fig. 51). The produce of the Banana is of great value to the inhabitants of warm countries. The same extent of ground which in wheat would only maintain two persons, will yield sustenance under the Banana to fifty. *Musa textilis* yields a kind of woody fibre, which is used in India in the manufacture of fine muslins. Manilla Hemp is the produce of *Musa textilis.* The woody tissues of many species of Musa is used for manufacture in warm climates. The young shoots of the

Banana are used as a culinary vegetable. The juice of the fruit and the lymph of the stem of Musa are slightly astringent and diaphoretic. *Urania* or *Ravenala speciosa* is the Water-tree of the Dutch, or the Traveller's tree of Madagascar, so called on account of the great quantity of water which flows from its stem or leaf-stalk when cut across. The juice of the fruit of Urania is used for dyeing.

1067. Order 190.—**Iridaceæ**, the Iris Family. (*Mono-epigyna.*) Perianth adherent, 6-parted, coloured, in 2, often unequal whorls (figs. 745, 746). Stamens 3, epigynous, opposite the outer segments of the perianth (figs. 745, 746 *e e*); filaments distinct or monadelphous; anthers 2-celled, extrorse. Ovary inferior (fig. 746 *o*), 3-celled; ovules numerous (fig. 746 *g*), anatropal; style 1; stigmas 3, often petaloid (fig. 746 *s*), sometimes bilabiate. Fruit a 3-celled, 3-valved capsule, with loculicidal dehiscence (fig. 448). Seeds numerous; embryo enclosed in horny or fleshy albumen; radicle next the hilum (fig. 747). —Herbs, rarely undershrubs, with rhizomes or underground corms, having their leaves often equitant or distichous, and their flowers spathaceous. Natives chiefly of warm and temperate regions. They



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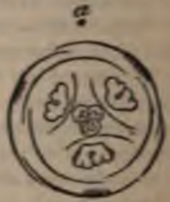

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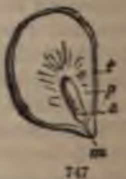

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Figs. 745-747.—Organs of fructification of Iris Germanica, to illustrate the natural order Iridaceæ.

Fig 745.—Diagram of the flower, showing six divisions of the perianth in two verticils, three extrorse stamens, and the 3-celled capsule with numerous ovules. *a*, Position of the axis of inflorescence.

Fig. 746.—Vertical section of the flower. *ce*, Outer divisions of the coloured perianth. Inner divisions of the perianth. *t*, Tube of the perianth, above the part which is adherent he ovary. *o*, Inferior 3-celled ovary. *g*, Numerous anatropal ovules. *e e*, Stamens. *s*, oid stigmas.

. 747.—Seed separated and cut longitudinally. *t*, Integuments (spermoderm). *p*, Peri- n. *e*, Embryo enclosed in the perisperm. *m*, Micropyle (foramen).

abound at the Cape of Good Hope. The Crocus occurs only in Europe and Asia. There are 55 known genera, and 550 species. *Examples*—Iris, Sisyrinchium, Witsenia, Gladiolus, Ixia, Crocus.

1068. Some of the plants have fragrant and stimulant, and some acrid, rhizomes and corms; others yield dyes. The root-stock of *Iris Florentina* yields orris-root, which has a pleasant odour like violets, and an acrid taste, depending on the presence of a volatile oil. It is imported from Florence and Leghorn. Orris-root is used chiefly for giving a pleasant odour to the breath, and in perfumery and tooth-powder. Orris-root starch is used for hair-powder. *Crocus sativas*, the כרְכם of the Old Testament, furnishes the colouring material called Saffron. It consists of the stigmata, which have a fine deep-orange colour. These stigmata are either dried in the loose state, forming Hay Saffron, or compressed into masses, constituting Cake Saffron. The yellow colouring ingredient is Polychroite, which possesses the property of being totally destroyed by the action of the solar rays, and of forming blue tints when treated with sulphuric and nitric acid. Saffron contains an active volatile oil, and it has been used in the form of tincture and syrup, as an emmenagogue and antispasmodic. The stigmata of *Crocus autumnalis* and *C. odorus*, also supply saffron. The roasted seeds of *Iris pseudacorus* have been used as a substitute for coffee.

1069. Order 191.—**Burmanniaceæ**, the Burmannia Family. (*Mono-epigyn.*) Perianth coloured, tubular, 6-cleft, the three outer segments (calyx) often keeled at the back, the three inner (petals) minute. Stamens 3, inserted in the tube of the perianth, opposite its inner segments, sometimes with 3 alternating sterile filaments; anthers dithecal, opening transversely, with a fleshy connective. Ovary inferior, either 1- or 3-celled, in the latter case the cells opposite the outer segments of the perianth; ovules 00; style simple; stigmas 3. Fruit a 1-3-celled, 3-valved capsule, crowned by the persistent perianth. Seeds 00, minute, striated.—Herbs, with radical leaves and bisexual flowers. Natives of moist grassy places in tropical regions. They have no properties of importance. There are about 13 known genera, and 43 species. *Examples*—Burmannia, Apteria, Apostasia?

1070. Order 192.—**Hæmodoraceæ**, the Blood-root Family. (*Mono-epigyn.*) Perianth petaloid, more or less woolly, 6-cleft. Stamens inserted on the perianth, either 3, and opposite the inner segments of the perianth, or 6; anthers introrse. Ovary adherent to the tube of the perianth, usually 3-celled, rarely 1-celled; ovules 1-2 or numerous; style simple; stigma undivided. Fruit a 3-valved capsule, sometimes indehiscent. Seeds either definite or 00, sometimes peltate; embryo in cartilaginous albumen.—Herbs with fibrous roots, equitant distichous leaves, and bisexual flowers. They are found in various parts of the world, more especially in the warm parts of South America at the

Cape of Good Hope, as well as in North America and Australia. Lindley mentions 13 genera, and 50 species. *Examples*—Hæmodorum, Anigosanthus, Velozia, Barbacenia.

1071. The plants receive the name of Blood-root, from the red colour of their roots, which are used for dyeing. *Vellozias*, Tree Lilies, give a decided feature to the vegetation of the mountains of Minas Geraes in Brazil. Their trunks are covered by the withered remains of the leaves, and their branches are dichotomous, and bear tufts of leaves at the extremities. The outer surface of their stems is covered thickly with numerous adpressed rootlets.

1072. Order 193.—**Amaryllidaceæ**, the Amaryllis Family. (*Monoepigynæ.*) (Fig. 251). Perianth petaloid, regular, 6-cleft, the outer segments overlapping the inner. Stamens 6, inserted in the perianth, sometimes cohering by the dilated bases, and forming a kind of cup; occasionally there are additional sterile stamens, which sometimes form a corona above the tube of the perianth; anthers introrse. Ovary inferior, 3-celled; ovules 00, anatropal; style 1; stigma 3-lobed. Fruit either a 3-celled, 3-valved capsule, with loculicidal dehiscence, or baccate. Seed with a thin or thick, or black and brittle spermoderm; albumen fleshy; embryo nearly straight; radicle next the hilum.—Usually bulbous plants, sometimes with fibrous roots; leaves ensiform, with parallel veins; flowers spathaceous; stem sometimes woody and tall. Natives chiefly of the Cape of Good Hope, but species are found in Europe, East and West Indies, South America, and Australia. Lindley enumerates 68 genera, and 400 species, and he divides them into 4 tribes:—1. Amarylleæ, bulbs, flowers without a corona. 2. Narcisseæ, bulbs, flowers with a corona. 3. Alstrœmerieæ, fibrous roots, outer segments of the perianth different in form from the inner. 4. Agaveæ, fibrous roots, both segments of the perianth alike. *Examples*—Amaryllis, Galanthus, Crinum, Narcissus, Alströmeria, Agave.

1073. The bulbs of many plants of this order have narcotic poisonous qualities. Some of them act as emetics, others are used in the preparation of a kind of intoxicating spirit. The tough fibres of some are used for flax. The root of *Hæmanthus toxicarius* is poisonous. The flowers of the Daffodil (*Narcissus pseudo-narcissus*) are also said to be poisonous. The fibres of *Agave Americana*, American Aloe, yield Pita flax. This plant does not flower often, but when flowering begins, it proceeds with great rapidity and vigour. Its roots are sometimes used to adulterate Sarza. Its juice is fermented so as to form an intoxicating beverage. *Agave Saponaria* is used in Mexico for washing. The bulbs of *Narcissus poeticus*, *N. Jonquilla*, *N. odorus*, *N. pseudo-narcissus*, *N. Tazetta*, and of some species of *Pancratium* are emetic. The uernsey Lily is also reputed poisonous. Some *Alströmerias* are diu-tic. In *Alströmerias* (fig. 251), the leaves are twisted, so that what should be the upper surface becomes the lower. In *Narcissus* the corona or crown of abortive filaments projects beyond the flower; while in *Pancratium* the dilated filaments of the fertile stamens unite together, and are included within the perianth. Many ornamental garden plants belong to the order.

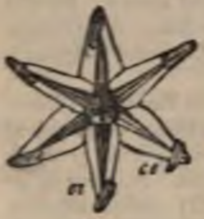
1074. Order 194.—**Hypoxidaceæ,** the Hypoxis Family. (*Mono-epigyn.*) Perianth petaloid, superior, usually 6-parted, regular. Stamens 6, inserted into the base of the segments of the perianth, filaments distinct; anthers introrse. Ovary inferior, 3-celled; ovules numerous, amphitropal; style simple; stigma 3-lobed. Fruit indehiscent, sometimes succulent, 1-2-3-celled. Seeds 00, with a lateral hilum and a beaked caruncle; testa black, and crustaceous; embryo straight, in the axis of fleshy albumen; radicle remote from the hilum. —Herbaceous and usually stemless plants, with tuberous and fibrous roots, radical plaited leaves, and simple or branched scapes. Natives of warm countries. Some have bitter roots, others have edible tubers. There are 5 known genera, including 60 species. *Examples*—Hypoxis, Curculigo.

1075. Order 195.—**Bromeliaceæ,** the Pine-apple Family. (*Mono-perigyn.*) Perianth tubular, 6-divided, in 2 verticils; outer whorl (calyx) persistent, more or less adherent to the ovary; inner petaloid, marcescent or deciduous, with imbricated æstivation. Stamens 6, inserted into the base of the segments of the perianth; anthers introrse. Ovary either free or partially adherent, 3-celled; ovules 00, anatropal; style single; stigma 3-lobed or entire, often twisted. Fruit capsular or succulent (figs. 256, 474), 3-celled. Seeds 00; embryo minute, curved or straight, lying in the base of mealy albumen; radicle next the hilum.—Stemless or short-stemmed plants, with rigid, channelled leaves, which are often spiny at the margin, and are covered with scurfy matter. Natives of the warm parts of America chiefly. There are 37 genera, according to authors, and 200 species. *Examples*—Bromelia, Ananassa, Tillandsia, Bonapartea.

1076. The plants of this order are all more or less epiphytic, being able to grow without any direct attachment to the soil. In hothouses they are frequently kept suspended in moistened moss. Some of the *Tillandsias* are hung from balconies in South America as air-plants. *Tillandsia usneoides* has the appearance of the Beard-moss (a lichen commonly seen on trees in Britain), and it is used for stuffing cushions, &c. The plant has been called Tree-beard or Black Moss. The leaves of *Tillandsias* frequently contain much water in their hollowed-out bases. The fruit of *Ananassa sativa* is well known as the Pine-apple or Ananas (fig. 256). It is an anthocarpous fruit, consisting of numerous flowers and bracts united together, and becoming succulent. The fruit is more or less acid in the wild state, but when cultivated it becomes sweet and highly aromatic. The fibres of the leaves are used in the preparation of fine muslins. The woody fibres of many *Bromelias* are used in manufactures. *Bromelia Pinguin*, is used as a vermifuge in the West Indies. Its ovaries do not combine into one mass, and therefore illustrate well the formation of the Pine-apple. The crown of the Pine-apple consists of the leaves arising from the prolonged axis (fig. 474 *f*).

b. Perianth free, Ovary superior, Flowers usually hermaphrodite.

1077. Order 196.—**Liliaceæ**, the Lily Family. (*Mono-perig.* and *Mono-hypog.*) Flowers usually bisexual. Perianth coloured, in 2 rows, regular, with 6 divisions (figs. 259, 260, 748, 749). Stamens 6 (fig. 538), perigynous, inserted into the segments of the perianth (figs. 259, 748, 749); anthers introrse (fig. 750 *e*). Ovary free, 3-celled (fig. 749); ovules 00; style 1; stigma simple or 3-lobed (figs. 259, 260, 750 *s*). Fruit 3-celled, either succulent or dry and capsular. Seeds numerous, packed one above the other in 1 or 2 rows (fig. 750); embryo in the axis of fleshy albumen (fig. 751).—Herbs, shrubs, or trees, with bulbs (figs. 207–209), or tubers, or arborescent stems, or rhizomes (fig. 90); leaves not articulated, usually narrow, with parallel veins. They are found both in temperate and tropical climates. In warm regions some of them are arborescent, as in the case of Dracænas; others are very succulent, as species of Aloe. The order has not been sufficiently defined, and there are still many differences of opinion as to its limits. Under it are included by some the following suborders:—



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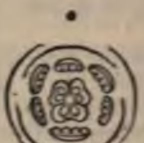
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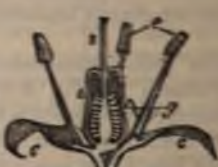

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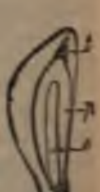

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1. Tulipeæ, Tulip tribe: bulbous plants, segments of perianth scarcely adherent in a tube, testa pale and soft.
2. Hermerocallideæ, Day-lily tribe: bulbous plants, with a tubular perianth, testa pale and soft.

Figs. 748-751.—Organs of fructification of Scilla autumnalis, to illustrate the natural order Liliaceæ.

Fig. 748.—Flowers seen from above. *ce*, Outer verticil of the perianth (calyx). *ci*, Inner verticil of the perianth (corolla).

Fig. 749.—Diagram of the flower, showing three outer and three inner leaves of the perianth, six alternating stamens in two rows, and three carpels of the ovary with the ovules.

Fig. 750.—Vertical section of the flower. *c c*, Perianth. *e*, Stamens. *o*, Ovary. *s*, Style and stigmas. *g*, Ovules attached to a placenta in the axis.

Fig. 751.—Seed separated and cut lengthwise. *t*, Integument. *p*, Perisperm. *e*, Embryo.

3. **Scilleæ or Allieæ, the Squill or Onion tribe:** bulbous (figs. 207-209), with the testa black and brittle.
4. **Anthericeæ or Asphodeleæ, Asphodel tribe:** not bulbous, roots fascicled (fig. 120) or fibrous, leaves not coriaceous nor permanent.
5. **Convallarieæ, Lily of the Valley tribe:** stem developed as a rhizome or tuber (fig. 90).
6. **Asparageæ, Asparagus tribe:** stem usually fully developed, arborescent, in some cases branched, leaves often coriaceous and permanent.
7. **Aloineæ, Aloes tribe:** stem usually developed, arborescent, leaves succulent.
8. **Aphyllantheæ, Grass-tree tribe:** having a rush-like habit and membranous imbricated bracts.

Lindley adds to these the tribes Conanthereæ, Wachendorfeæ, Aspidistreæ, and Ophiopogoneæ. He enumerates 155 genera, including 1,250 species. *Examples*—Tulipa Lilium; Hemerocallis, Phormium; Anthericum, Asphodelus; Convallaria; Asparagus, Dracæna; Aloe; Aphyllanthes, Xanthorrhæa; Conanthera; Wachendorfia; Aspidistra; Ophiopogon.

1078. Many of the plants of this order are showy garden flowers, such as Tulips, Lilies, Fritillaries, Day-lilies, Tuberoses (*Polianthes*), and Dog-tooth-violets (*Erythronium*). Some of them are used medicinally as purgatives, stimulants, emetics, and diaphoretics. Some yield valuable fibres, others supply resinous matter. The bulb of *Scilla* or *Squilla* (*Urginea*) *maritima* supplies the officinal squill. The plant grows on the sandy coasts of the Mediterranean. Its bulbs vary in weight from half a pound to four or five pounds. In their fresh state they are very acrid. They contain a bitter crystalline principle called Scillitina. Squill is used medicinally in the form of powder, vinegar, syrup, and tincture, as an emetic, diaphoretic, expectorant, and diuretic. The drug called Aloes is the inspissated juice of the leaves of various species of *Aloe*, as *A. spicata*, *vulgaris*, *socotrina*, *indica*, *rubescens*, *arabica*, *linguæformis*, and *Commelini*. It is imported under the names of Socotrine, East Indian or Hepatic, Barbadoes, Cape and Caballine Aloes. It contains a substance called Aloesin, which some regard as its active principle. Aloes is used medicinally as a cathartic, acting chiefly on the large intestines and on the rectum. The bulb of *Allium sativum*, Garlic, is used as an irritant, stimulant, and diuretic. It is the שׁוּם of the Bible, the *σκόροδον* of the Greeks. The bulb of *Allium Cepa*, the Onion, the בָּצָל of the Bible, is used in the same way as garlic, and so is the bulb of *Allium Porrum*, the Leek, the חָצִיר of the Bible (figs. 207, 208). Besides the Onion and Leek, several species of *Allium*, under the name of Chive (*A. Schœnoprasum*), Shallot (*A. ascalonicum*,) and Rocambole (*A. Scorodoprasum*), are used as articles of diet. These plants contain free phosphoric acid, and a sulphuretted oil, which is in a great measure dissipated by boiling or roasting. In the Oregon and Missouri districts of North America, the bulbs of *Gamassia esculenta*, Gamass or Squamash, are also employed in a similar manner. It is called by the Indians Biscuit-root. The turios or young shoots sent up from the underground stem of *Asparagus officinalis* (fig. 110), are the parts employed in cooking. The bulbs of species of *Lilium*, found in the east of Siberia, are eaten like potatoes. Fibres are procured from *Phormium tenax*, New Zealand Flax, and from the species of *Yucca*, Adam's Needle (fig. 234). *Dracæna Draco*, and other species, yield an astringent resin called Dragon's-blood. The *Dracænas* often branch in a dichotomous manner, and attain a large size. The Grass-tree of New South Wales, *Xanthorrhœa hastilis*, gives a peculiar feature to the vegetation of that country. It yields a yellow gum-like substance. The base of the inner leaves of some Grass-trees is used as food. Some of the Lilies have bulbils or bulblets in the axils of their leaves (fig. 213). In the Crown-Imperial there is a nectariferous depression in the base of the segments of the perianth (fig. 302). *Lilium chalcedonicum* is said to be the Lilies of the field, *τα κρίνα του ἀγρου*, mentioned in Scripture. *Hyacinthus orientalis* is the common cultivated Hyacinth, of which the Haarlem florists had at one time upwards of 2,000 varieties. The mania for Tulip bulbs was at one time carried to a great extent, and the price given for approved kinds was enormous. Many hundred varieties of tulips are known.

1079. Order 197.—**Melanthaceæ,** the Colchicum Family. (*Monoperigyn.*) Perianth petaloid, in 6 pieces, which are sometimes slightly coherent, usually involute in æstivation. Stamens 6; anthers extrorse. Ovary 3-celled; ovules numerous; style 3-parted; stigmas 3, undivided. Fruit a 3-celled capsule, with septicidal or loculicidal dehiscence. Seeds with a membranous spermoderm; albumen dense, fleshy; embryo very minute.—Plants with bulbs, tubers (fig. 93), or fibrous roots, having parallel-veined leaves, sheathing at the base. The flowers are sometimes polygamous. They are natives of various parts of the globe, but are most abundant in northern countries. The order has been divided into three suborders:—1. Veratreæ or Melantheæ, rhizome fibrous, dehiscence of capsule septicidal, flowers frequently unisexual. 2. Colchiceæ, rhizome bulbous, dehiscence septicidal. 3. Uvularieæ, rhizome bulbous or fibrous, dehiscence loculicidal. There are 33 known genera, and 136 species. *Examples*—Melanthium, Veratrum, Tofieldia; Colchicum; Uvularia.

1080. The plants of the order have in general poisonous properties. Many are acrid, purgative, and emetic, and some are narcotic. Among the medicinal plants of the order, the most important is *Colchicum autumnale*, Meadow Saffron, or Autumn Crocus. The bulb or corm (fig. 93) and the seeds are the officinal parts. They contain a peculiar alkaloid called Colchicia, which seems to be analogous to Veratria. Colchicum in large doses acts as a narcotico-acrid poison. In medicinal doses, in the form of extract, vinegar, tincture, and wine, it is used in the cure of gout and rheumatism. It is sedative, cathartic, and diuretic. The rhizome of *Veratrum album*, the White Hellebore of the Greeks, is an irritant narcotic poison, its properties being due to the presence of an alkaloid called Veratria. It has been used as an emetic and purgative, especially in mania, and it has been administered as a remedy for gout. Cevadilla is the fruit of *Helonias* or *Asagræa officinalis*, as well as of *Veratrum Sabadilla*. The fruit and seeds contain the alkaloid veratria in combination with a peculiar fatty acid called cevadic or sabadillic acid. Cevadilla is used in cases of neuralgia and rheumatism.

1081. Order 198.—**Gilliesiaceæ**, the Gilliesia Family. (*Mono-perigyn.*) Perianth 6-parted, sometimes 5-parted by cohesion of two of the pieces, in a double row; the outer, petaloid and herbaceous; the inner, smaller, and more coloured; æstivation twisted. Stamens in a double series; outer whorl sterile, in the form of a 6-toothed urceolate body, or of scale-like bodies, one of which forms a sort of labellum; inner whorl of six stamens, of which three are sometimes sterile. Ovary superior, 3-celled; style 1; stigma simple. Fruit a 3-celled, 3-valved capsule, with loculicidal dehiscence. Seeds numerous, attached to the axis; spermoderm black and brittle; embryo curved in the midst of fleshy albumen.—Herbs with tunicated bulbs, grass-like leaves, and umbellate spathaceous flowers. Natives of Chili. Their properties unknown. The description of the flower is in accordance with Arnott's view, and differs from that of Lindley, who considers the perianth as bracts, and the outer verticil of stamens as the perianth. There are 2 genera and 5 species. *Examples*—Gilliesia, Miersia.

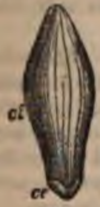
1082. Order 199.—**Pontederiaceæ**, the Pontederia Family. (*Mono-perigyn.*) Perianth tubular, coloured, 6-parted, more or less irregular; æstivation circinate. Stamens 3-6, perigynous; anthers introrse. Ovary free, or slightly adherent, 3-celled; ovules numerous, anatropal; style 1; stigma simple. Fruit a 3-celled, 3-valved capsule, with loculicidal dehiscence. Seeds 00, attached to a central axis; testa membranous; hilum small; embryo straight, in the axis of somewhat mealy albumen; radicle next the hilum. Aquatic or marsh plants with sheathing, parallel-veined leaves, which are sometimes cordate or sagittate, and have inflated petioles. The flowers are spathaceous. They are natives of North and South America, East Indies, and Africa. Their properties are unimportant. There are 6 genera, according to Lindley, and 30 species. *Examples*—Pontederia, Leptanthus.

1082. Order 200.—**Xyridaceæ**, the Xyris Family. (*Mono-perigyn.*) Perianth 6-parted, in two verticils; the outer glumaceous, the inner petaloid. Stamens 6, 3 fertile, inserted into the claws of the inner perianth; anthers extrorse. Ovary single, 1-celled; ovules 00, orthotropal, attached to parietal placentas; style trifid; stigmas obtuse, multifid or undivided. Fruit a 1-celled, 3-valved capsule. Seeds numerous; embryo on the outside of mealy albumen, remote from the hilum.—Herbs having a sedge-like aspect, with radical leaves, equitant and sheathing at the base, and scaly heads of flowers. Natives chiefly of tropical regions, having no important properties. There are about 7 genera, and 72 species. *Examples*—Xyris, Abolboda, Philydrum?

1084. Order 201.—**Juncaceæ**, the Rush Family. (*Mono-hypoperigyn.*) Perianth 6-parted, more or less glumaceous. Stamens 6, inserted into the base of the segments, sometimes 3, and opposite the outer segments; anthers 2-celled, introrse. Ovary 1-3-celled; ovules 1, 3, or many in each cell, anatropal; style 1; stigmas generally 3, sometimes 1. Fruit a 3-valved capsule, with loculicidal dehiscence, sometimes indehiscent. Seeds with the testa neither black nor crustaceous; embryo very minute, near the hilum, within fleshy or cartilaginous albumen.—Herbs with fasciculated or fibrous roots, hollow, grooved, or flat leaves, with parallel veins. They are natives chiefly of the colder regions of the globe. Many species of *Juncus* are used for making the bottoms of chairs, mats, &c., and the central cellular tissue forms the wicks of rushlights. There are 18 known genera, and upwards of 210 species. *Examples*—Juncus, Luzula, Narthecium, Astelia.

1085. Order 202.—**Palmæ**, the Palm Tribe. (*Mono-perigyn.*) Flowers bisexual or unisexual, or polygamous. Perianth 6-parted in a double row (fig. 757); 3 outer (calyx) fleshy, or leathery and persistent (figs. 752 *c e*, 756 *c*), 3 inner (corolla) often larger (fig. 752 *c i*), and sometimes deeply connate. Stamens 6 (figs. 753, 757), rarely 3, sometimes 00, inserted into the base of the perianth. Ovary free, 1-3-celled, usually composed of 3 carpels, which are more or less completely united (fig. 755); ovules 1-3. Fruit drupaceous, or nutlike (fig. 756), or baccate, often with a fibrous covering. Seed with cartilaginous or horny albumen (fig. 520), which is often ruminate (fig. 497), or furnished with a central or lateral cavity; embryo small, cylindrical, or flat, in a cavity of the albumen, remote from the hilum (figs. 497, 520).—Arborescent plants (fig. 115, 1), with simple, rarely branched trunks, marked with the scars of the leaves, which are terminal, pinnate, or fan-shaped, with plicate vernation, and parallel simple veins, and often spiny petioles. Flowers on a terminal, often branched spadix, enclosed in a 1- or many-valved spatha. Natives of tropical regions chiefly, and imparting to them much of their botanical physiognomy. Most of them have unbranched stems, attaining sometimes a height of 190 feet, and sending out clusters of large leaves, from the axil of which bunches of flowers proceed. Although the flowers are small, still the inflorescence, taken collectively, has often a most imposing aspect. Humboldt describes their effect on the landscape in glowing colours, and Martius has illustrated the order by splendid delineations. Linnæus called them the Princes of the Vegetable

Kingdom. Lindley states that there are 73 known genera, and 400 species; but this estimate probably falls short of the total amount, for much still remains to be done in the elucidation of the species.



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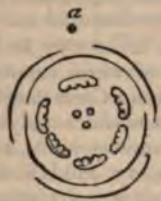

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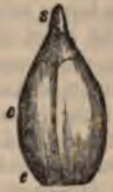

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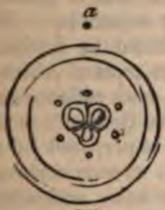

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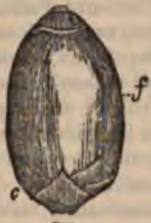

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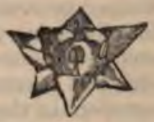

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Martius estimates the known species at 582, of which 91 have fan-shaped leaves. They have been divided by him into various tribes, depending chiefly on the nature of the ovary, ovules, and fruit; and sections are formed according as the leaves are pinnate or flabelliform, and the stems are spiny or not. The following are the tribes:—1. Arecineæ, the Betel-nut tribe. 2. Lepidocaryinæ, the Sago tribe. 3. Borassinæ, the Palmyra Palm tribe. 4. Coryphinæ, the Talipot and Date tribe. 5. Cocoinæ, the Coco-nut tribe. *Examples*—Areca, Euterpe, Caryota; Lepidocaryum, Calamus, Sagus; Borassus, Lodoicea; Corypha, Livistona, Phœnix; Cocos, Elais, Acrocomia; Phytelephas.

1086. The properties of the plants of this order are very various. In the countries in which they grow, they are used for supplying food,

Figs. 752-756.—Organs of fructification of Areca Catechu, Betel-nut Palm, to illustrate the natural order Palmæ.

Fig. 752.—Unexpanded flower-bud. *c e*, Outer division of the perianth. *c i*, Inner perianth

Fig. 753.—Diagram of the flower, showing the two verticils of the perianth, the six stamens, and three abortive carpels. *a*, The position of the axis of inflorescence in reference to the flower.

Fig. 754.—A flower deprived of its perianth, in which the stamens, *e*, are partly abortive, while the ovary, *o*, is developed. *s*, Stigma.

Fig. 755.—Diagram of the last flower, showing the double perianth, the partially abortive stamens, and the 3-celled ovary. *a*, Axis of inflorescence.

Fig. 756.—Fruit, *f*, surrounded at its base by the persistent perianth, *c*.

Fig. 757.—Flower of Chamærops humilis, European Fan-Palm, seen from above. There are six divisions of the perianth, six stamens, and the ovary.

and for forming habitations. The fruit of some is eatable, while that of others is extremely hard. Many supply oil, wax, starchy matter, and sugar, which is fermented so as to form an intoxicating beverage. Their fibres are employed for ropes, and the reticulum surrounding their leaves is sometimes manufactured into brushes.

The Palm of the Bible, תָּמָר, seems to be *Phœnix dactylifera*, the Date, the drupaceous fruit of which supplies food to many of the inhabitants of Arabia and Africa. *Cocos nucifera* (fig. 115, 1), the Coco-nut Palm, is one of the most useful, supplying food, clothing, materials for houses, and utensils of various kinds, ropes and oil. The sugar procured from it is called Jagery, and is fermented so as to form arrack. The fibrous part of its fruit is manufactured into Coir-rope. The wood of the Coco-nut Palm is known by the name of porcupine wood. The terminal bud of the Coco-nut Palm, as well as that of *Euterpe montana*, the Cabbage Palm, are used as culinary vegetables. The Double Coco-nut of the Seychelles islands is produced by *Lodoicea Seychellarum*. The palm-oil imported from the west coast of Africa is obtained by bruising the fruit of *Elais guineensis* and *melanococca*. The oil-bearing palms are in the tribe Cocoinæ. The Betel-nut is the produce of *Areca Catechu*, and from it an extract is prepared of an astringent nature resembling Catechu. The seeds or nuts form an ingredient in the Eastern masticatory called Pan or Betle, and which seems to owe its stimulating properties to the leaves of the Piper Betel. Sago, and starchy matter allied to it, is obtained from many Palms. It is contained in the cellular tissue of the stem, and is separated by bruising and elutriation. Fine Sago is said to be procured from *Metroxylon læve*, a native of Borneo and Sumatra; *Sagus Rumphii* or *farinifera*, a native of Malacca; and *Saguerus Rumphii* or *saccharifer*, which is found in the eastern islands of the Indian Ocean. After the starchy matter is washed out of the stems of these Palms, it is then granulated so as to form sago. A single tree, it is said, will yield 500 to 600 pounds. The last-mentioned Palm also furnishes a large supply of sugar. Sago, as well as sugar and a kind of Palm-wine, are procured from *Caryota urens*. The date sugar of Bengal is the produce of *Phœnix sylvestris*. *Ceroxylon* or *Iriartea Andicola* yields wax, which forms a coating over its trunk. *Copernicia cerifera*, Carnahuba Palm, is another wax palm. Its trunks are imported into Britain, and have been used for veneering. It is much used in the northern parts of Brazil, as at Aracaty, for thatch, hats, packsaddles, stakes, and palisades. The wax is procured by shaking the leaves, which have a glaucous bloom. Each leaf will yield fifty grains. A reddish resinous matter is yielded by *Calamus Draco*. It is one of the substances called Dragon's-blood, and is used for colouring. The whalebone-like bristles which surround the base of the leaves of some species of *Sagus* and *Saguerus* are used for brushes. The thinner stems of Palms, as of

Calamus Scipionum and *Rotang*, are used as canes under the name of Rattans. *Calamus Rudentum*, the Cable Cane, a native of the East Indies, Cochin-China, and the Moluccas, grows sometimes to the length of 500 feet. The fruit of *Attalea funifera* is known by the name of Coquilla-nuts, and its hard pericarp is used for making umbrella-handles, &c. It seems to supply a fibre used in manufacture under the name of Piassaba. The hard albumen of *Phytelephas macrocarpa* is used in the same way as ivory. Hence the plant is called the Ivory Palm. The spatha of *Manicaria saccifera* comes off in the form of a conical cap, and is used as a covering for the head in the West Indies. *Chamærops humilis* is the only European species of Palm. It is able to stand the climate of this country with slight protection during winter. A specimen in the Edinburgh Botanic Garden has lived in the open air for years. It is covered with matting during winter. The Doom-palm of Egypt (*Hyphæne thebaica*) has a trunk which divides in a dichotomous manner. Its pericarp is used as food, and has the taste of gingerbread. *Acrocomia sclerocarpa* is the Macahuba-palm of Brazil; *Mauritia vinifera* is the Buriti-palm, the stem of which, when perforated, yields a reddish juice, having the taste of sweet wine. The following Palms have flowered in the Edinburgh Botanic Garden—various species of *Chamædorea*, *Euterpe montana*, *Chamærops humilis*, *C. Palmetto*, *Livistona chinensis*, *Harina caryotoides*, *Areca triandra*, *Sabal umbraculifera*, *Phœnix sylvestris*, *Caryota urens*, *C. sobolifera*, *Seaforthia elegans*, *Rhapis flabelliformis*, *Calamus Wightii*, *Desmoncus elongatus*.

1087. Order 203.—**Commelynaceæ**, the Spider-wort Family. (*Mono-hypogyn.*) Perianth in 2 verticils; outer (calyx) herbaceous and tripartite; inner (corolla) petaloid, tripartite or trifid. Stamens 6 or fewer, hypogynous, some of them occasionally abortive or deformed; anthers introrse. Ovary 3-celled; ovules few in each cell; style 1; stigma 1. Fruit a 2-3-celled, 2-3-valved capsule, with loculicidal dehiscence. Seeds often in pairs, with a lateral and linear hilum; embryo pulley-shaped, antitropal, in a cavity of fleshy albumen, remote from the hilum.—Herbs with flat narrow leaves, which are usually sheathing at the base. Natives chiefly of warm climates. Some have fleshy rhizomes, which are used for food. *Tradescantias*, Spider-worts, have moniliform staminal hairs, in which a microscopic movement of granules is seen (fig. 225). Genera 17, species 264. *Examples*—Commelyna, Tradescantia, Mayaca.

1088. Order 204.—**Alismaceæ**, the Water-plantain Family. (*Mono-hypog.*) Perianth in 6 divisions and 2 verticils; outer whorl usually herbaceous; inner usually petaloid; sometimes the perianth is wanting. Stamens definite or 00, hypogynous; anthers introrse or extrorse; ovaries 3, 6, or more, distinct or united; ovules erect or ascending, solitary or in pairs. Styles and stigmas equal to the number of carpels. Fruit of several dry, indehiscent carpidia. Seeds 1-2 in each carpel, exalbuminous (fig. 525); embryo straight, or curved like a horse-shoe; radicle next the hilum.—Plants growing in flowing or stagnant water, usually with a creeping rhizome, parallel-veined leaves, and hermaphrodite or unisexual flowers. Natives both of tropical and temperate regions. The limits of the order are not well defined. It has been divided into two suborders:—1. Alismeæ, inner perianth petaloid, anthers introrse, embryo curved or hooked. 2. Juncagineæ, inner perianth herbaceous, sometimes perianth 0, anthers extrorse, embryo straight, plumule coming through a slit in the embryo (fig. 504). They have few important properties. Some are acrid, others have eatable rhizomes. Various Brazilian Sagittarias are very astringent; their expressed juice being employed in the preparation of ink. There are 6 known genera, and about 74 species. *Examples*—Alisma, Sagittaria; Triglochin, Scheuchzeria.

1089. Order 205.—**Butomaceæ**, the Flowering-rush Family. (*Mono-hypog.*) Perianth of 6 parts, in 2 verticils (fig. 381, 2); outer usually herbaceous; inner petaloid. Stamens definite (fig. 381, 2, *eo*, *ei*), or 00, hypogynous. Ovaries 3, 6, or more, distinct or united, 1-celled (fig. 381); ovules 00; stigmas simple, as many as the carpels. Fruit consisting of several follicles, which are either distinct (fig. 393) and beaked, or combined. Seeds 00, minute, attached to the whole inner surface of the pericarp (fig. 394), exalbuminous; embryo often curved like a horse-shoe; radicle next the hilum.—Aquatic plants, often lactescent, with paralled-veined leaves, and frequently umbellate flowers. They are chiefly found in northern countries, and some of them have acrid and bitter properties. *Butomus umbellatus*, Flowering-rush, is the only British plant in the class Enneandria of Linnæus. Authors give 5 genera, including 8 species. *Examples*—Butomus, Limnocharis.

c. Flowers incomplete, often unisexual, without a proper perianth, or with a few verticillate scales.

1090. Order 206.—**Pandanaceæ**, the Screw-pine Family. (*Mono-hypog.*) Flowers unisexual or polygamous, covering the whole of the spadix. Perianth 0, or a few scales. Male flowers: stamens numerous; filaments with single anthers, which are 2-4-celled. Female flowers: ovaries 1-celled, united in parcels; ovules solitary or numerous, anatropal; stigmas sessile, equal to the carpels in number. Fruit either fibrous drupes collected into parcels, or berries. Seeds solitary in the drupes, numerous in the berries; embryo at the base of fleshy albumen; radicle next the hilum.—Trees or bushes, sometimes with adventitious roots (fig. 115, 2), long, imbricated, amplexicaul leaves, usually with spiny margins and backs. Natives of tropical regions.

The order is subdivided into two sections:—1. Pandaneæ, undivided leaves and no perianth. 2. Cyclantheæ, fan-shaped or pinnate leaves, flowers with a few scales. There are 25 genera, according to authors, and 85 species. *Examples*—Pandanus, Freycinetia; Cyclanthus, Carludovica, Nipa.

1091. The flowers of some of the plants are fragrant, and their seeds are sometimes used as food. The juice has in some instances astringent properties. The species of *Pandanus* are remarkable for their aerial roots, with large cup-like spongioles. These roots are sent out regularly from all parts of their stems, and appear like artificial props (fig. 115, 2). Their spermoderm has numerous raphides. Their leaves are arranged in a spiral manner in three rows, and in their aspect they have some resemblance to those of the pine-apple—hence the name Screw-pine. *Pandanus Candelabra* is the Chandelier-tree of Guinea, and is so called on account of its mode of branching.

1092. Order 207.—**Araceæ,** the Arum Family. (*Mono-hypog.*) Flowers generally unisexual, rarely bisexual, enclosed within a spatha, and usually on a spadix (fig. 239), having male flowers at its upper part, female below, and abortive flowers between them (fig. 239, 2). Perianth either 0, or in the ☿ flowers rudimentary and scaly. Stamens definite or 00, hypogynous; anthers extrorse. Ovary free, 1- 3- or more celled; ovules solitary or numerous; style short or 0; stigma simple. Fruit succulent or dry, indehiscent, one- very rarely three-celled; seeds one or several; embryo in the axis of fleshy or mealy albumen, sometimes with a lateral cleft for the plumule; radicle usually next the hilum.—Herbaceous or shrubby plants, often with tubers or creeping rhizomes, leaves sheathing at the base, and having parallel or branching veins (fig. 239, 1). They occur in dry and marshy places and in lakes in various parts of the world, abounding in the tropics. The order has been divided into four suborders:—1. Arineæ, Cuckoo-pint tribe (fig. 239); naked flowers with a spadix and spatha, ♂ ♀, anthers sessile, ovules several, fruit succulent, seeds pulpy. 2. Typhineæ, Bulrush-tribe; marsh or ditch plants, with nodeless stems, flowers ♂ ♀, with a scaly or hairy perianth, arranged on a spadix without a spatha, anthers wedge-shaped on long filaments, ovule solitary, fruit dry, seed with adherent pericarp. 3. Acoreæ, Sweet-flag tribe; flowers ☿, having usually a scaly perianth, arranged on a spathaceous spadix, ovules 1 or more, fruit a berry. 4. Pistieæ, Duckweed tribe; flowers ♂ ♀, naked, enclosed in a spatha without a spadix, ovary 1-celled, ovules 2 or more, fruit membranous or capsular. The order includes 60 genera, and 286 species. *Examples*—Arum, Caladium, Colocasia, Calla; Typha, Sparganium; Acorus, Orontium, Pothos; Pistia, Lemna.

1093. The general property of the order is acridity. Sometimes the plants are dangerous irritant poisons. In some instances the rhizomes yield much starchy matter, and when boiled or roasted, are used as substitutes for yams, under the name of Coco. The starch may be separated and used as Arrow-root. Thus, Portland Sago is prepared from the rhizome of *Arum maculatum*, common Cuckoo-pink, or Wake-Robin. *Dieffenbachia seguina* (*Caladium seguinum*), is called Dumb-cane, on account of the swelling of the tongue caused by chewing the plant. Many of the plants of this order give out heat in a marked degree during flowering (¶ 475). Some send out aerial roots, by means of which they climb upon trees. *Dracontium pertusum* has perforated leaves (¶ 137). *Symplocarpus fœtidus*, Skunk-cabbage, has a very disagreeable odour. Its rhizome and seeds have been used as antispasmodics. *Richardia africana*, with its white spatha, is commonly cultivated under the name of Æthiopian Lily. The root-stock of *Acorus Calamus*, Sweet-flag, has an aromatic odour, combined with a bitterish acrid taste. It has been used as a stimulant and tonic. In *Typha latifolia*, Great Reed Mace, the pollen is abundant and easily collected, and from its inflammable nature has been used as a substitute for the Lycopodium spores. The young shoots of *T. latifolia* and *angustifolia* are eaten by the Cossacks like asparagus. The large, fleshy, amylaceous rhizomes are eaten by the Kalmucks. *Lemnas*, Duckweeds, are common in ditches in temperate regions. Their flowers are very simple, one male, and the other female, without a perianth, enclosed in a membranous bag; their roots are simple fibres, covered with a sheath. *Pistia Stratiotes* floats in lakes in tropical countries.

1094. Order 208.—**Naiadaceæ** or **Potameæ**, the Naias or Pondweed Family. (*Mono-hypog.*) Flowers hermaphrodite or unisexual. Perianth of two or four herbaceous or scaly pieces, often deciduous, sometimes 0. Stamens definite, hypogynous. Ovary free, of one or more carpels; ovule solitary; style 1 or 0; stigma entire, rarely 2-3 parted. Fruit dry, 1-celled, usually indehiscent. Seed solitary, erect, or pendulous, exalbuminous; embryo straight or curved, usually with a lateral slit for the plumule (fig. 758); radicle large (figs. 499, 758).—Plants living in fresh and in salt water, having cellular leaves with parallel veins and inconspicuous flowers. They are found in various parts of the world. They have no properties of importance. *Zostera marina* is used in the dried state for stuffing mattresses, and has been recommended for hospitals. *Ouvirandra* (*Hydrogeton*) *fenestralis* has peculiar skeleton-like leaves (fig. 131). *Aponogeton distachyum*, a Cape aquatic, has grown well for many years in the open pond of the Edinburgh Botanical Garden. *Caulinia fragilis* is one of the plants in which Rotation has been observed. There are 19 known genera, and upwards of 70

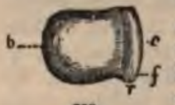

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Fig. 758.—Embryo of Zostera, in the natural order Naiadaceæ. *c*, Cotyledon. *r*, Radicle. *b*, Lateral swelling connected with the radicle. *f*, Slit for the plumule, which lies in a cavity of the very large radicle.

species. *Examples*—Naias, Zannichellia (fig. 505), Potamogeton (fig. 130), Ruppia, Zostera.

1095. Order 209.—**Restiaceæ,** the Restia or Cord-rush Family. (*Mono-perigyn.*) Flowers frequently unisexual. Perianth glumaceous, sometimes 0. Stamens definite, perigynous, when two or three in number opposite the inner glumes; anthers usually 1-celled. Ovary 1 or more celled, sometimes composed of several carpels; ovules solitary, pendulous; styles and stigmas 2 or more. Fruit capsular or nucumentaceous. Seeds pendulous; embryo lenticular, outside mealy albumen, remote from the hilum.—Herbs or undershrubs, with narrow simple leaves or none, naked or sheathed culms, and spiked or capitate, bracteated flowers. They are found chiefly in America and New Holland. They have few properties of importance. The tough wiry stems of *Willdenovia teres* and some *Restias*, are used for making baskets and brooms. *Eriocaulon septangulare* is a native of Britain, being found in the Isle of Skye, as well as in the west of Ireland. In Brazil there exist branched *Eriocaulons* six feet high. In 1764, Linnæus described only 5 species of Eriocaulon in all the world, while Gardner collected in Brazil 100 species. The Diamond districts of Brazil are great centres of *Eriocaulons*. There are according to Lindley, 36 genera, and 372 species. *Examples*—Restio, Centrolepis, Eriocaulon.

Subclass 3.—Glumiferæ.

1096. Flowers glumaceous, consisting of bracts or scales, which are imbricated, and not arranged in true verticils. Leaves with parallel veins.

1097. Order 210.—**Cyperaceæ,** the Sedge Family. (*Mono-hypog.*) Flowers hermaphrodite or unisexual, generally without a perianth. Each flower furnished with a solitary bract (glume or scale). These bracts are imbricated upon a common axis, and the lowermost are often empty. Occasionally they enclose two or three opposite membranous bracts or glumes. (In the female flower of Carex, the two inner bracts receive the name of Perigynium.) Stamens hypogynous, definite, 1-12; anthers dithecal, innate. Ovary 1-celled, often surrounded by hypogynous bristles (setæ) which are probably abortive filaments; ovule erect, anatropal; style single, 2-3-cleft; stigmas undivided, sometimes bifid. Fruit a crustaceous or bony achænium or nut (fig. 519); embryo lenticular, enclosed within the base of fleshy or farinaceous albumen (fig. 519 *e*); plumule inconspicuous (fig. 759).—Grass-like herbs with fibrous roots. Their stems are solid, often without joints, sometimes creeping

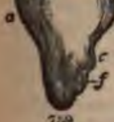

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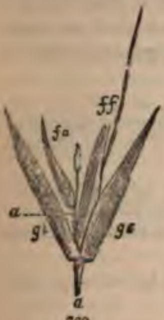
Fig. 759.—Embryo of Carex depauperata, separated to show the structure of that body in the natural order Cyperaceæ *r*, Radicle. *c a*, Cotyledon. *f*, Slit for the plumule.

(fig. 91), frequently angular. The leaves are narrow, and their sheaths are entire, not slit. They are found in all quarters of the globe, and in various localities, from the sand on the shore, to the tops of the mountains. Many of them occur in marshy ground. Lindley enumerates 120 genera, including 2,000 species. *Examples*—Cyperus, Eriophorum, Scirpus, Fuirena, Cladium, Schœnus, Scleria, Elyna, Carex.

1098. None of the plants of the order possess important medicinal qualities. The creeping stems of *Carex arenaria*, *disticha*, and *hirta*, are diaphoretic and demulcent, and have been used in medicine under the name of German Sarsaparilla. *Papyrus antiquorum* is the Papyrus of the Nile, the cellular tissue of which was used in the manufacture of paper. Some say that the word גֹּמֶא in the Bible, translated Bulrush, is either the *Papyrus* or a species of *Cyperus*. The word עָרוֹת has been translated Paper-Reeds. The species of *Eriophorum* are called Cotton-grass, on account of the woolly-like substance which is attached to the base of the ovary. Some species of *Cyperus* have tubers at the lower part of their stems, which are used as food. The roots of *Cyperus longus* have been used as bitter and tonic remedies, while those of *C. odoratus* are aromatic. Some species of *Scirpus* are used for making chair bottoms. Some of the *Carices*, with their creeping stems, tend to bind together the loose sand on the sea-shore.

1099. Order 211.—**Gramineæ**, the Grass Family. (*Mono-hypogyn.*) Flowers usually ☿, sometimes unisexual or polygamous; 1, 2, or more (some occasionally abortive), are attached to a common axis, and enclosed within bracts, the whole together forming a locusta or spikelet (figs. 760–762). The outer imbricated bracts are called glumes; they are usually 2 (figs. 760, 761 *g e g i*), sometimes 1, rarely wanting, and often unequal. They are either awned (aristate) or awnless (muticous). The bracts enclosed within the glumes are called paleæ or glumellæ; they immediately enclose the stamens, are usually 2, the lower being simple, and the upper being formed of 2 united by their margins (fig. 761 *p e p i*). The innermost set of bracts consists of two or three hypogynous scales (squamulæ, glumellulæ, or lodiculæ), which are either distinct or combined (fig. 763 *p*), and are sometimes wanting. Stamens hypogynous, 1-6 or more; anthers dithecal, versatile (figs. 337, 763 *e*). Ovary simple (fig. 763 *o*); ovule ascending, anatropal; styles 2 (fig. 763) or 3, sometimes united; stigmas feathery or hairy (fig. 410, 763 *s s*). Fruit a caryopsis (fig. 467). Seed incorporated with the pericarp; embryo lenticular, lying on one side of farinaceous albumen (fig. 495), near its base (figs. 764, 765); endorhizal in germination (fig. 124).—Herbaceous plants, with cylindrical, hollow (fig. 111), and jointed stems, called culms; alternate leaves, with a split sheath and a membranous expansion at the junction of the petiole and blade, called a ligule (fig. 194), the collections of flowers (locustæ) being arranged in spikes, racemes, or panicles.

Discussions have arisen as to the true nature of the paleæ in grasses. Brown thinks that the upper palea is composed of two parts united, while the inferior palea is the third part. The arrange-



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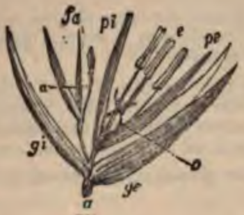

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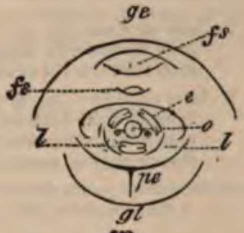

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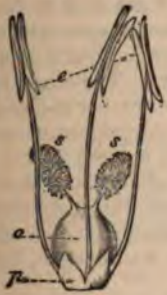

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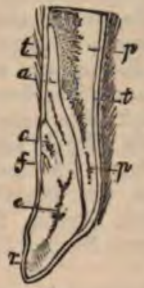

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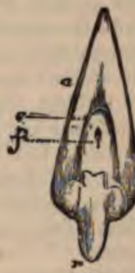

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Figs. 760-765.—Organs of fructification of Avena sativa, common cultivated Oat, to illustrate the natural order Gramineæ.

Fig. 760.—Spikelet of the Oat. *a*, Axis of inflorescence or rachis. *g e*, Exterior or lower glume. *g i*, Inner or upper glume. *f f*, Inferior fertile flower, *f a*, Two upper abortive flowers.

Fig. 761.—The same spikelet with the envelopes separated to show the internal parts. *a a*, Axis of inflorescence. *g e*, Outer glume. *g i*, Inner glume *p e*, Outer palea of the fertile flower, with its awn (arista). *p i*, Inner palea, cleft at the apex, and apparently formed by two united. *e*, Three stamens. *o*, Pistil consisting of the ovary, and two styles. *f a*, Two abortive flowers.

Fig. 762.—Diagram of the spikelet. *g e*, Outer glume. *g i*, Inner glume. *p e*, Outer palea with awn; the inner palea being opposite. *e*, Stamens. *o*, Pistil. *l l*, Scales or lodiculæ. *f s*, *f s*, Barren flowers.

Fig. 763.—Fertile flower deprived of glumes and paleæ. *e*, Three stamens with versatile cleft anthers. *p*, Scales (squamæ or lodiculæ) partially united. *o*, Ovary ultimately forming the grain, which consists of pericarp and seed combined. *s s*, Two styles with feathery stigmas.

Fig. 764.—Vertical section of the Caryopsis (fruit or grain), with the upper portion cut off. *t t*, Integuments of the caryopsis and of the seed united. *p p*, Perisperm. *e*, Embryo. *r*, Radicle. *c a*, Cotyledon. *f*, Slit corresponding to the plumule.

Fig. 765.—Embryo separated. *r*, Radicle. *c a*, Cotyledon. *f*, Slit corresponding to the plumule

ment is thus trimerous, and bears a relation to the scales or lodiculæ. Mohl, on the other hand, states, that the inferior palea is not on a level with the other, and is in fact a bract from which the other is developed. From their alternate position, the parts of the flowers of grasses are in general looked upon as bracts, rather than as parts of a true perianth. The following may be given as a general view of the parts of the flower.

1. Outer envelope: One or two glumes, the calyx of some authors, containing one or more flowers, with distinct insertions on a common axis. When one glume is suppressed it is the exterior or lower.
2. Inner envelope: One or two paleæ, corolla of some authors, calyx of *Jussieu*. Inner or upper palea sometimes suppressed. This palea (valve) consists usually of two confluent valves, as shown by two ribs equidistant from the axis. Hence this envelope is, according to some, a ternary perianth.
3. Squamulæ (scales, lodiculæ, or glumellulæ), occur within the last envelope, and at the base of the ovary.

Grasses are found in all quarters of the globe, and are said to form about $\frac{1}{22}$ part of known plants. In tropical regions they sometimes assume the appearance of trees. They generally grow in great quantity together, so as to receive the name of social plants. The order has been divided into numerous sections, founded on the number of flowers in a spikelet, their hermaphrodite, unisexual, or polygamous nature, the number and form of the different sets of bracts, and the nature of the fruit. Lindley enumerates 320 genera, including about 3,850 species. *Examples*—Oryza, Zea, Phalaris, Panicum, Stipa, Agrostis, Arundo, Echinaria, Chloris, Avena, Bromus, Festuca, Bambusa, Lolium, Triticum, Hordeum, Nardus, Rottboellia, Andropogon, Saccharum.

1100. This is one of the most important orders in the vegetable kingdom, whether we regard it as supplying food for man, or herbage for animals. To the former division belong the nutritious cereal grains, as Wheat (*Triticum*), Oats (*Avena*), Barley (*Hordeum*), Rye (*Secale*), Rice (*Oryza*), Maize (*Zea*), Guinea-corn and Millet (*Sorghum* and *Panicum*); to the latter, the various pasture grasses, as Rye-grass (*Lolium*), Timothy-grass (*Phleum*), Meadow-grass (*Poa*), Cock's-foot-grass (*Dactylis*), Sweet-Vernal-grass (*Anthoxanthum*), Fescue (*Festuca*), Dog's-tail-grass (*Cynosurus*), &c. The grains of many other grasses are used for food. *Zizania aquatica* supplies a kind of rice in Canada, *Setaria germanica* yields German millet, *Panicum miliaceum* gives a kind of millet in India, and *Andropogon Sorghum* has been sent to this country under the name of Durra, an Indian grain. *Phalaris canariensis* is the source of the common Canary seed. The cereal grains have been so extensively distributed by man, that all traces of their native country are lost. They seem to be in many instances examples of permanent varieties or races kept up by cultivation; some say that wheat is a cultivated variety of *Ægilops ovata*. Their grain or caryopsis contains a large amount of starch (figs. 35, 36) and gluten. The grasses used for fodder in some parts of the world attain a large size, such as *Anthistiria australis*, the Kangaroo-grass of New Holland, *Tripsacum dactyloides*, the Gama-grass of Mexico, and *Dactylis cæspitosa*, the Tussac-grass of the Falkland islands. Some of these are five or six feet in height, and are, nevertheless, sufficiently delicate to be used as food for animals. The Tussac has been introduced into this country, and it thrives well in peaty soils within the influence of the sea spray.

1101. Sugar is a valuable product obtained from many grasses. It has been procured in Italy from *Sorghum saccharatum*, sweet Sorgho; in China, from *Saccharum sinense;* in Brazil, from *Gynerium saccharoides;* in the West Indies, from *Saccharum violaceum;* and in many other parts of the world, from *S. officinarum*. The last two are commonly known as Sugar-cane, and they are generally considered as varieties of a single species, *Saccharum officinarum*, which is now widely spread over various parts of the world. Six or eight pounds of the saccharine juice of the plant yield one pound of raw sugar. The following were the imports of unrefined sugar into Great Britain in 1859:—

British West Indies and Guiana	3,215,223 cwts.
Mauritius	1,130,386 —
British East Indies	877,971 —
Java and Philippine Islands	476,091 —
Cuba, Porto-Rico, and Brazil	2,906,148 —
Other Countries	383,064 —
Total	8,988,883 cwts.

1102. Some grasses have a very agreeable fragrance. This has been remarked in *Anthoxanthum odoratum*, which is hence called sweet-scented vernal grass, and is said to impart the odour to new-made hay. This odour has been referred to the presence of benzoic acid. A fragrant oil is procured from some species of *Andropogon*, as *A. Schœnanthus*, Lemon-grass, and *A. Calamus aromaticus*, which seems to be the קָנֶה, or קְנֵה בֹשֶׂם the Sweet-cane of the Bible. Grasses contain a large quantity of siliceous matter in their stalks. This is deposited so as to form part of their structure, and in some cases it accumulates in the joints. The tabasheer in the joints of *Bambusa arundinacea*, the Bamboo, is composed of silica. This is one of the tree-like branching grasses, which sometimes attains a height of fifty or sixty feet. It shoots up with great rapidity. In the Edinburgh Botanic Garden the young shoots attain a height of thirty or forty feet in a few months; and the late superintendent (Mr. W. M'Nab) measured, during a long summer day, a growth of the young stem to the extent of nine inches.

Most of the species of Bamboo have hollow stems, which often attain a diameter of many inches. Gardner mentions a large species of Bamboo (*B. Tagoara*) having a stem 18 inches in circumference, and attaining a height of 50 to 100 feet. The touch-paper of the Chinese is made from a variety of Bamboo, by beating the young shoots flat, steeping them in a lime pit for a month, and then washing and drying. A kind of paper is made from the Bamboo in India. Its young shoots are used as pickles. The hollow stems of some reeds in warm climates supply refreshing water to travellers.

1103. The stems of some grasses run under ground, and form a sort of net-work, which is useful in consolidating the sand of the sea shore. *Elymus arenarius* and *Ammophila* (*Psamma*) *arenaria* constitute the Bent and Marram of the British shores. This tendency to creep under ground renders some grasses, such as *Triticum repens*, Couch-grass, difficult of extirpation. The grains of some grasses are used for ornaments. Beads are made from those of *Coix Lachryma*, commonly called Job's-tears, from their form and hardness. A few grasses, as *Bromus purgans* and *catharticus*, have purgative properties; and one, *Lolium temulentum* (*infelix lolium*), Darnel-grass, is poisonous. Some suppose that it is the ζιζάνια, tares, of Scripture. The grains of Rye, and other grains, are liable to a disease called Ergot, depending on the attack of a fungus which alters the texture of the ovary, and makes it assume an elongated spurred form. The Ergot of Rye, or spurred Rye, has a peculiar effect in promoting the contraction of the uterus, and is on this account used in medicine. Ergotted rye, when regularly used for food, has the effect of causing what has been called convulsive and gangrenous ergotism, the former disease being distinguished by insensibility and convulsions, ending in death; the latter by dry gangrene, which attacks the fingers and toes, causing sloughing of these parts, and sometimes proving fatal by exhaustion. The poisonous effects of Ergot are attributed to the presence of a fixed oil.

SECTION II.—CRYPTOGAMOUS PLANTS.

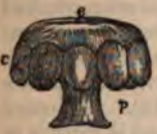
CLASS III.—ACOTYLEDONES, *Juss.* CELLULARES AND MONO-CRYPTOGAMÆ, DC. THALLOPHYTA AND ACROBRYA, *Endlich.* THALLOGENS AND ACROGENS, *Lindl.*

1104. The plants belonging to this class are in some instances composed entirely of *cellular tissue*; in other instances both cells and vessels are present. The *vascular tissue* in the higher orders consists partly of closed spiral and scalariform (fig. 62) vessels. Many of them have no true stem nor leaves. The *woody stem*, when present, consists of simultaneous vascular bundles, which increase in an acrogenous manner (¶ 103). The stem of Tree-ferns (which illustrates this class) is unbranched, more or less uniformly cylindrical, hollow in the interior, and marked by the scars of the leaves (fig. 116). *Stomata* occur in the epidermis of the higher divisions. *Leaves*, when present, have frequently no true venation, at other times the venation is forked. There are no *flowers*, and no distinct stamens nor pistils. *Reproduction* takes place in some cases apparently by the union of cells of different kinds (antheridia and pistillidia) (¶ 492), by means of which germinating bodies called *spores* are formed (fig. 498). In other cases it is difficult to trace this process of fertilization. The *spore* may be considered as a cellular embryo which has no cotyledons, and germinates from any part of its surface, being heterorhizal (¶ 591, fig. 530).

Subclass 1.—ACROGENÆ OR CORMOGENÆ.*

1105. Acotyledons, having usually distinct stems and leaves, stomata, a certain amount of vascular tissue, and thecæ or cases containing spores. This subclass corresponds in a great measure with the division of Cormophyta, called Acrobrya by Endlicher, and with the Foliosæ or Ætheogamæ of De Candolle.

1106. Order 212.—**Equisetaceæ**, the Horse-tail Family. Stem striated, hollow, usually branched, containing much silica in its composition, articulated, the joints being separable, and surrounded by a membranous toothed sheath. There are no true leaves, green-coloured branches having a straight vernation occupying their place. The cuticle exhibits a longitudinal series of stomata. A spiral structure is observed in some of the vessels. Reproductive organs collected into cones; spore-cases (thecæ or sporangia) attached to the lower surface of peltate polygonal scales (fig. 766), and opening by an internal



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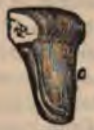

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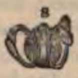

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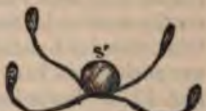

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* 'Ακρα, summit, κορμός, a stalk or stem, and γεννάειν, to produce.

Figs. 766-769.—Reproductive organs of Equisetum, to illustrate the natural order Equisetaceæ.

Fig. 766.—A peltate or polygonal scale, *e*, taken from the terminal cone-like fructification of an Equisetum. *c*, Thecæ or spore-cases arranged in a verticil on the under surface of the scale. *p*, Stalk by which the scale is attached to the axis.

Fig. 767.—*c*, Spore-case seen on its inner surface, with the slit or opening by which the spores are discharged.

Fig. 768.—A spore, *s*, with the two clavate filaments rolled up in a spiral manner around it.

Fig. 769.—Spore, *s*, with the two filaments, which are clavate at each extremity, unrolled. These filaments or elaters are hygrometric, and move about under the influence of moisture.

longitudinal fissure (fig. 767); spores in the form of rounded cells, surrounded by 2 elastic, club-shaped, hygrometric filaments or elaters (figs. 768, 769).—Plants with simple or branched stems, the branches being jointed and placed in whorls at the articulations of the stem, each whorl consisting of as many branches as there are teeth in the sheath. Found in ditches, lakes, and rivers, in various parts of the world. In South America, Gardner measured an *Equisetum* fifteen feet high, and three inches in circumference at the lower part of the stem. There is only 1 known genus, comprehending about 12 species. *Example*—Equisetum.

1107. From the quantity of silicic acid contained in them, some of the species of *Equisetum* are used in polishing mahogany. An analysis of them is given at ¶ 226. The spiral filaments which surround their spores are interesting objects under the microscope, exhibiting marked movements according to the moisture or dryness of the atmosphere around them. The stomata are arranged in lines on the cuticle. In *Equisetum hyemale*, often called Dutch Rushes, the siliceous stomatic apparatus is well seen after the action of nitric acid on the stem. There are regular rows of tubercles of a siliceous nature, in each of which is a transverse fissure, and at the bottom of the fissure a stoma is placed, with its opening at right angles to that of the tubercle. Each portion of the stoma has a pectinated (comb-like) appearance. The distinctions between the species of Equisetum are founded on the nature of the fertile and barren stems, the number of striæ or furrows, and the number of teeth at the articulations.

1108. Order 213.—**Filices**, the Fern Family. Stem, a rhizome (fig. 770), which creeps along or under the surface of the ground, emitting descending roots and ascending fronds (leaves), or which rises into the air so as to form an acrogenous trunk (fig. 116). This trunk (stipe) is of nearly uniform diameter, is hollow in the interior, marked on the hard outer rind by the scars (cicatrices) of the leaves, and contains vascular bundles of woody, dotted, and scalariform vessels, which are enclosed in hard plates, and are arranged in an irregular manner (fig. 117). Sometimes the trunk is dichotomous (fig. 118). The outer fibrous covering is formed by the bases of the leaves, and is thicker at the lower than at the upper part of the stem. The leaves (fronds) have a circinate (gyrate) vernation (fig. 770 *f′ f″*); their veins are generally of equal thickness, and either simple or dividing in a forked manner (fig. 771), or somewhat reticulated, and occasionally stomata occur. Reproductive organs, consisting of spore-cases (thecæ, sporangia), which arise from the veins on the under surface of the fronds (figs. 770 *f″″*, 771 *s*, 772), or from their margin. Spore-cases, either stalked, with the pedicel passing round them in the form of an elastic ring (fig. 773), or sessile and destitute of a ring. The thecæ sometimes arise from the surface of the frond, while at other times they spring from below, having a cuticular covering in the form of an indusium or involucre (fig. 771). The clusters of thecæ are called sori (fig. 772). The margin of the frond sometimes is folded so as to cover the thecæ, and at times the whole frond is converted into clusters of thecæ. The subject of embryogenic growth in Ferns has latterly attracted much attention. It is now believed that the prothallium simultaneously bears antheridia and archegonia. The antheridia occur in the under surface of the prothallium, and consist of cellular papillæ, having a central cavity. This cavity contains free cellules, within each of which a ciliated spiral filament or spermatozoid rests. This cavity discharges those cellules by a rupture at its apex. The spiral filaments then burst the cellules, and being set free reach the cellular body containing the embryo-germ, or archegonial cell, embedded in the substance of the prothallus. The archegonia are larger than the antheridia, and present a canal leading to the germ-cell, which canal remains closed till the period when the spermatozoid is matured. Mercklin noticed spermatozoids entering the canal of the archegonium. After fertilization the archegonial cell enlarges, developes numerous cellules, and forms the true sporangiferous frond of the fern.—Ferns abound in moist insular climates. They characterize the New Zealand Flora. They are elegant leafy plants, occurring chiefly in moist insular climates, and abounding in the tropical islands. In mild and warm climates they occur in the form of large Tree-ferns, fifty to sixty feet high, which give a char-

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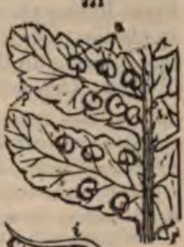

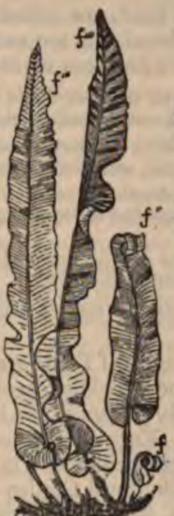

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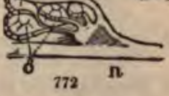

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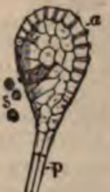

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Fig. 770.—Rhizome of Scolopendrium officinale, with several fronds (leaves), *f'*, *f''*, *f'''*, *f''''*, in different degrees of development. In *f'* and *f''*, the circinate or gyrate vernation is seen. In *f''''*, the linear transverse sori or clusters of thecæ are seen, having the appearance of dark lines on the lower surface of the frond.

Figs. 771-773.—Frond and fructification of Polystichum angulare, to illustrate the natural order Filices.

Fig. 771.—Part of the frond seen on the lower surface. *p*, Two pinnæ covered with sori, *s*, having an indusium. *r*, Rachis or central stalk of the frond.

Fig. 772.—One of the sori or clusters of thecæ cut vertically. *n*, The vein bearing it. *i*, Indusium or fold of the frond covering it. *c*, Thecæ or sporangia (spore-cases).

Fig. 773.—One of the thecæ separated at the period of dehiscence. *a*, Incomplete annulus or ring, which is elastic, and causes transverse dehiscence of the theca. *p*, Stalk of the theca. *s*, Spores discharged.

acter to the landscape. The theca of ferns has been looked upon as a modified leaf, having the same gyrate or circinate development as the frond. Leaves have occasionally been produced in place of thecæ. Ferns having the thecæ on the back of the frond, and furnished with an elastic ring or band, are called dorsiferous and annulate; while those having no thecal ring are exannulate.

1109. The order has been divided into several suborders:—

1. Polypodieæ, thecæ on the back of the frond, pedicellate or sessile, distinct, annulate, ring vertical, usually incomplete, bursting irregularly and transversely.
2. Hymenophylleæ, thecæ marginal or dorsal, nearly sessile, distinct, annulate, ring horizontal, complete, occasionally oblique, bursting lengthwise.
3. Osmundeæ, thecæ dorsal, or forming a separate stalked mass (an altered frond), distinct, with a terminal or dorsal ring more or less incomplete, bursting lengthwise.
4. Ophioglosseæ, thecæ collected into a spike, formed at the edges of an altered frond, distinct, exannulate, two-valved.
5. Danæeæ, thecæ united in masses, exannulate, opening irregularly by a central cleft.

The generic characters of Ferns are founded on the position and direction, covered or uncovered nature of the sori, as well as on the venation. Lindley notices 240 genera in his Filical Alliance, including upwards of 2,000 species. Kunze estimates the species at 3,000. There are not above 700 species cultivated in Europe. In 1846 there were 387 species grown in the Royal Garden at Kew. *Examples*—Polypodium, Aspidium, Lastrea, Grammitis, Adiantum, Pteris, Davallia, Woodsia, Cyathea; Hymenophyllum, Trichomanes, Aneimia, Lygodium; Osmunda; Ophioglossum, Botrychium; Danæa.

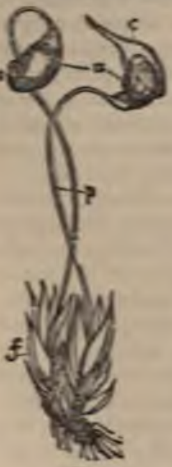
1110. Few of the Ferns are used medicinally. They are in general demulcent and astringent. Some yield food. The rhizome of *Lastrea Filix-mas*, Male-shield fern, has been used as a vermifuge, especially in cases of tape-worm. It contains starch, gum, saccharine matter, tannin, green fixed oil, and resin. Its properties are ascribed to the fixed oil. The rhizome has been used for tanning, and its ashes contain much carbonate of potash. The syrup called capillaire, and certain pectoral mixtures are prepared from *Adiantum pedatum* and *A. Capillus Veneris*. The rhizome of *Pteris esculenta* is used as food in Australia, and that of *Marattia alata* in the Sandwich islands. Many other species of Ferns are esculent. The stems and leaf-stalks of Ferns are often covered with scales, and with woolly matter. One (*Davallia canariensis*) is called Hare's-foot Fern on this account, and another (*Aspidium Baromez*) receives the name of Scythian or Tartarian-lamb, because, when prepared in a particular way, it resembles that animal.

1111. Order 214.—**Marsileaceæ**, or **Rhizocarpeæ**, the Pepperwort Family. Stem wanting. Leaves often stalked, with the lamina divided into three or more wedge-shaped pieces, sometimes the lamina is abortive; vernation circinate. Reproductive organs near the root or along the petiole, enclosed in an involucre; these organs are of two kinds:—1. Stalked or sessile clustered membranous sacs, containing minute granules, which some consider as pollen; hence the bodies are called anthers. 2. Membranous sacs, containing cells which divide into four, one of which only is developed as a germinating body; the sacs have been called ovule-sacs, and the single developed cell is considered by some as an ovule which is impregnated by the so-called pollen. The thecæ are the bodies from which germination proceeds.—Creeping or floating plants, found in ditches and pools in various parts of the world, more especially in temperate climates. They are not put to any important use. There are 4 genera, and upwards of 20 species. *Examples*—Marsilea, Pilularia, Salvinia.

1112. Order 215.—**Lycopodiaceæ**, the Club-moss Family. Stems creeping or corms; annular vessels in the axis. Leaves imbricated, more or less setaceous, sometimes subulate. Thecæ axillary and sessile, 1-3-celled, opening by valves or indehiscent; often of two kinds. One, round, reniform, or crescentic, consisting of antheridian cells, with spermatozoids; the other, called oophoridium (ᾠὸν, an egg, and φορέω, I bear), of a roundish or tetrahedral form, opening by two valves, and enclosing four large spores capable of germinating; these spores contain an internal prothallus on which archegonia are formed. In *Isoetes* the two kinds of reproductive bodies are embedded in the substance of the base of the leaf.—They are moss-like plants, intermediate between ferns and mosses, and in some respects allied to cone-bearing plants. A species of Lycopodium from Jamaica has a green hue during the day, and turns white to the eye at night. They abound in warm, moist, insular climates. There are 6 genera, and about 200 species. *Examples*—Lycopodium, Selaginella, Isoetes.

1113. Some of the *Lycopodiums* are emetic and cathartic. The powdery matter in the thecæ is inflammable, and has been used as a substitute for sulphur, under the name of Lycopode or vegetable brimstone. It is also employed to cover pills, so as to prevent their being acted upon by moisture. *Lycopodium squamatum*, a Brazilian species, coils up into a ball during the dry season, and unrolls during the wet season.

1114. Order 216.—**Musci**, the Moss Family. Plants having a distinct axis of growth, often giving off branches or innovations; no vascular system. Leaves minute and imbricated (fig. 774 *f*), entire, or serrated; sometimes with condensed cells in the form of ribs or nerves. Reproductive organs of two kinds:—1. Antheridia (fig. 368), cylindrical or fusiform stalked bags, containing minute cells with spermatozoids (fig. 368, 3), and mixed with empty jointed filaments or paraphyses (παράφυσις, an offset). 2. Urn-shaped pistillidia (fig. 777), enclosed at first within a calyptra (καλύπτρα, a covering), which is ultimately carried up with them (fig. 775 *c*), leaving often a sheath (vaginula) round the bottom of the fruit-stalk. These pistillidia finally become the thecæ (fig. 774) or spore-cases, supported on a stalk or seta which has leaves at its base, called perichætial (περί, around, and χαίτη, a bristle) leaves; on removal of the calyptra, the theca is found to consist of a case with an operculum or lid (fig. 776), which, when it falls off, shows the mouth of the urn either naked or crowned with a peristome (περί, around, and στόμα, mouth), consisting of one or more rows of teeth (in number, four, or a multiple of four), distinct, or united in various ways (fig. 776 *p*). In the centre of the theca is a columella (fig. 777 *c*), and the bag formed between it and the parietes of the theca, contains spherical cells called spores, each of which divides into four small spores or sporules, the germinating bodies (fig. 777).



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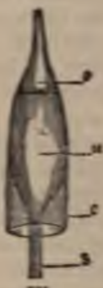

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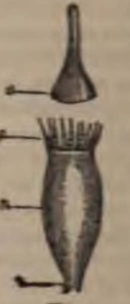

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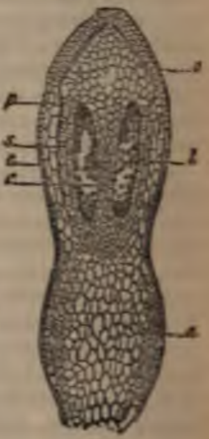

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Figs. 774-777.—Figures to illustrate the natural order Musci.

Fig. 774.—Funaria hygrometrica slightly magnified. *f*, Leaves, those connected with the seta being called perichætial. *u*, Urn-like theca, sporangium or spore-case supported on a long twisted stalk or seta, *p*. *c*, Calyptra, which exists on one of the thecæ, and has fallen from the other. *o*, Operculum or lid.

Fig. 775.—Theca of Encalypta vulgaris. *u*, Theca or spore-case. *c*, Mitriform entire calyptra. *o*, Operculum or lid. *s*, Top of the seta. The calyptra is transparent, and the operculum and theca are seen through it.

Fig. 776.—The same theca, *u*, with the calyptra removed. *o*, Operculum detached, showing the peristome, *p*, with its sixteen cilia or teeth.

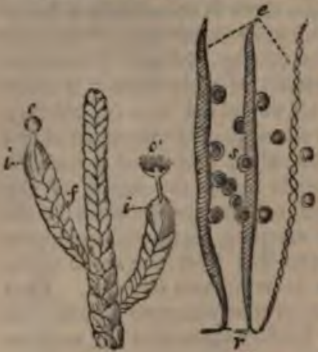
Fig. 777.—Very young theca of Splachnum cut longitudinally. *a*, Apophysis or swelling of the seta at the base of the theca. *c*, Central columella. *s*, Cavity or bag between the columella and the walls of the theca, containing spores. The integument of the theca is formed of different cellular layers; the first, *e*, forms the epidermis, and is thickened at the summit to form the operculum; there are then two intermediate layers, which ultimately form the teeth of the ristome; and lastly, an inner integument, *t*, which forms the parietes of the spore-bearing vity.

In some cases the operculum remains persistent and the theca opens by four valves. At the base of the theca there is occasionally a fleshy protuberance at one side called a struma, or a swelling of the seta called an apophysis (ἀποφύσις, excrescence), (fig. 777 *a*). The calyptra is sometimns split on one side (dimidiate), at other times it is entire (fig. 775 *c*) or split into short clefts all round its base (mitriform). Between the teeth of the peristome and the edge of the theca, an elastic ring or annulus is formed; and occasionally a horizontal septum or epiphragm (φρᾶγμα, a partition) extends across the mouth of the thecæ. The setæ are sometimes twisted, and so are the teeth of the peristome.—Mosses are either erect or creeping, terrestrial or aquatic plants found in all moist countries, extending from the arctic to the antarctic regions. They abound most in temperate climates. They are among the first plants which appear on newly-formed islands. In speaking of the morphology of mosses, Lindley states that the calyptra may be considered as a convolute leaf, the operculum another, the peristome one or more whorls of minute flat leaves, and the theca itself as the excavated distended apex of the seta. I have a specimen of *Tortula fallax*, which I received from the late Mr. E. Quekett, in which leaves appear at the top of the seta in place of the spore-case.

1115. Mosses have been divided according as their seta is terminal (*acrocarpi*, ἄκρα, summit, and καρπὸς, fruit), or lateral (*pleurocarpi*, πλευρὰ, side), according as the operculum is adherent or not, and according as the mouth of the theca is naked, or has a single or double peristome. Divisions have also been adopted, founded on the position of the antheridia and pistillidia, &c. Lindley separates Andræa from true Mosses, on account of its spore-case opening by four valves. According to him there are 70 known genera, and upwards of 1,200 species. *Examples*—Andræa, Phascum, Gymnostomum, Splachnum, Orthotrichum, Dicranum, Bryum, Funaria, Polytrichum, Hypnum, Sphagnum.

1116. Order 217.—**Hepaticæ**, the Liverwort Family. Plants having an axis which either bears cellular leaves (fig. 778), or is leafless and is bordered by a membranous expansion or thallus. Stomata are found in the epidermis of some. The reproductive organs are—1. Antheridia, which are either embedded in the frond, or situated on rounded sessile and stalked receptacles. 2. Pistillidia, either enclosed in involucres and solitary (fig. 778 *i i*), or occurring at the edge of the frond, or on the lower side of stalked peltate expansions (fig. 412). Thecæ or developed pistillidia, having no operculum, opening irregularly, or by four valves (fig. 778). Spores (fig. 498) often mixed with spiral filaments called Elaters (fig. 779). Heterorhizal in germination (fig. 530).—Terrestrial plants found in damp places, or inhabiting water; some having a moss-like appearance. They are natives both of cold and warm climates, and are generally distributed over the globe.

1117. The order has been divided into three sections:—1. chantieæ: thecæ collected in bursting irregularly, no oper spores with elaters. 2. Junge nieæ: thecæ solitary, opening b valves, no operculum, spore elaters. 3. Riccieæ: thecæ s decaying so as to allow the to escape, no operculum, no (fig. 411). Many of the He produce gemmæ or buds, whi developed on the frond in th of cup-shaped receptacles, an mately fall off so as to becom tinct plants. *Marchantia hemis* has been recommended in dr cases. There are, according to Lindley, 73 genera, and abo species. *Examples*—Marchantia, Jungermannia, Riccia.



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Subclass 2.—THALLOGENÆ* OR CELLULARES.

1118. Acotyledons composed entirely of cellular tissue, havi distinct axis, nor leaves, nor stomata, propagated by means of s which are often enclosed in asci. It corresponds to Endlicher's sion of Thallophyta, and includes the Amphigamæ of De Candolle

1119. Order 218.—**Lichenes**, the Lichen Family. Plants form a thallus, which is either foliaceous, crustaceous (fig. 780), or pulve lent; these different forms depending on the mode in which the c are developed and combined. The reproductive organs appear on th frond in the form of protuberances of various kinds, consisting of a outer layer of thick-walled roundish cells, more dense than the tiss of the thallus, and of a different colour (fig. 782 *c c*), and of an inter medullary layer of paraphyses and sporangia, lying perpendicular to the outer layer (figs. 782 *c m*, 781 *t p*). The fructification gradu projects more from the surface, and either remains covered with th outer layer, or bursts through it. When it remains closed, there is nucleus in the centre. When the fructification bursts through th cortical or outer layer, it expands in the form of shield-like discs, call apothecia (ἀποθήκη, a repository), or patellæ (figs. 780 *s*, 781 *a*) (*patella*, a hollow disk), or linear expansions called lirellæ (*lira*, a furrow). Sometimes the cortical matter forms a border round the fructification, at other times it grows up in the form of a stalk, so as to give rise to a podetium (ποῦς, a foot). The young thecæ (asci) contain spores, varying from 4 to 8 (fig. 413), or from 12 to 16. Occasionally, the spores are in sets of two (fig. 413, 2). Separated cells of the medullary layer, of a green colour, called gonidia (γόνη, generation, and εἶδος, resemblance), or gongyli, are considered as another kind of reproductive organ. There are also capsular bodies called spermogones, containing minute linear cells or spermatia, which are often supported on stalks or sterigmata. Besides these, pycnides or bodies like spermogones occur, containing spore-like cells, called stylospores.*—Lichens are found in all quarters of the globe, adhering to stones, rocks, trees, &c. They derive much of their nourishment from the atmosphere. They have the power of acting on hard rocks, so as to disintegrate them; and many of them contain much inorganic matter in their composition. They all grow in the air; none are found submersed. Genera 60, species 2400. *Examples*—Urceolaria, Umbilicaria, Lecidea, Cladonia, Parmelia, Cetraria, Roccella, Evernia.

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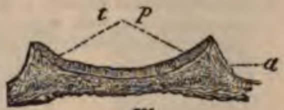
* Θαλλός, a green leaf, γεννάω, I produce.

Figs. 778, 779.—Organs of fructification of Jungermannia, [illegible] order Hepaticæ.

Fig. 778.—*f*, Branches covered with imbricated leaves, [illegible] of the branches bearing thecæ, supported on stalks whi [illegible] *i i*, Involucres. *c*, Theca closed in the young state. *c'*, [illegible] the spores and elaters.

Fig. 779.—*r*, Receptacle bearing elaters, *e*, or spiral [illegible] spiral fibre. *s*, Free spores.



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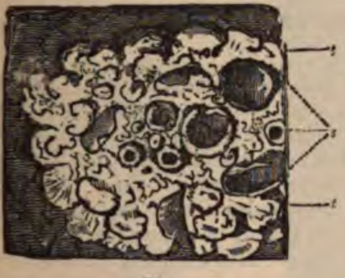

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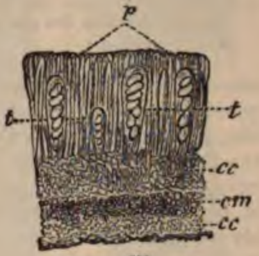

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* See Dr. Lauder Lindsay's paper on Lichens, in Trans. Royal Soc. Edin., vol. xxii.

Figs. 780-782.—Organs of fructification of Parmelia Acetabulum, to illustrate the natural order Lichenes, section Hymenothalameæ.

Fig. 780.—*t*, Thallus of the Lichen. *s*, Apothecia in the form of shields in different degrees of development.

Fig. 781.—Apothecium, *a*, cut vertically and magnified in order to show the layer, *t p*, formed by the union of thecæ and paraphyses.

Fig. 782.—A small portion of the apothecium much more magnified, showing, *c m*, the central medullary layer. *c c*, The cortical layer. *t t*, Thecæ in different degrees of development. *p*, Paraphyses.

1120. The order has been divided into four sections:—

1. Hymenothalameæ (ὑμήν, a membrane, θάλαμος, a receptacle): shields open, discoid permanent nucleus bearing the sporangia on its surface (fig. 780).
2. Gasterothalameæ (γαστὴρ, a belly): shields either closed always, or opening by bursting through the cortical layer of the thallus, the nucleus containing the deliquescing or shrivelled sporangia.
3. Idiothalameæ (ἴδιος, peculiar): shields closed at first, opening afterwards, containing free spores in a nucleus composed of the gelatinous remains of the paraphyses and sporangia.
4. Coniothalameæ (κόνις, powder), pulverulent lichens; shields open, without a nucleus, cavity filled with free spores.

1121. Lichens furnish articles of food and important dyes. *Cetraria islandica*, commonly called Iceland Moss, contains a nutritious matter called Lichenin, or Lichen-starch. There exists in it a bitter principle also, to which the name Cetrarin has been given. The plant is used as a demulcent and tonic, in the form of decoction or jelly. *Cladonia rangiferina* is a Lichen upon which the Reindeer feeds. Several species of *Gyrophora* constitute the Tripe de Roche, on which Franklin and his companions subsisted for some time. Many other Lichens, such as *Sticta pulmonaria* and species of *Lecanora*, furnish articles of food. *Roccella tinctoria* from the Canaries, and *R. fuciformis*, furnish valuable dyes, under the name of Orchil or Archil. The dye procured from them, and from other Lichens, is called Litmus. *Lecanora tartarea* supplies the dye called Cudbear. *Parmelia parietina* contains a yellow colouring matter called Parietin or Chrysophanic acid. Some species of *Variolaria* contain a large quantity of oxalate of lime. Some plants of the order are aromatic.

1122. Order 219.—**Fungi**, the Mushroom Family. The plants belonging to this order consist of cells, sometimes round, sometimes elongated in the form of filaments, either placed closely together or separated. They are variable in their consistence, being soft or hard, fibrous or gelatinous, fleshy or leathery. They never contain green gonidia like Lichens, and they rarely grow in water. There exists a vegetative system called spawn or mycelium (μύκης, fungus), formed of elongated, simple, or articulated filaments, concealed within the matrix, or expanded over its surface, from which varied forms of fructification proceed. The mycelium occurs either in a filamentous, a membranous, a tubercular, or a pulpy form. The reproductive organs consist of spores or spherical cells (usually 4 or some multiple of 4), which are either attached to the cellular tissue, and supported often on simple or branched filamentous processes (fig. 785, 787 *b*) called sporophores (σπορὰ, a spore, and φορέω, I bear) or basidia (βάσις, a base); or are contained in thecæ (*theca*, a sac), cystidia (κύστις, a bladder), or asci (ἀσκός, a bag), (fig. 785 *c*), accompanied with bodies called antheridia or paraphyses; in the latter case, the term sporidia ometimes applied to the spores. The sporophores sometimes end elicate cells bearing the spores, and called sterigmata (στήριγμα, a port). In the Agarics or Mushrooms, which are among the best

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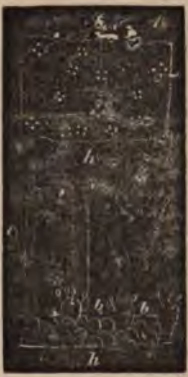

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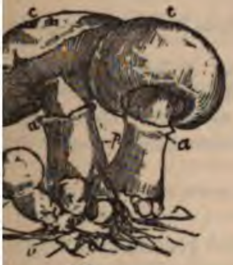

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wn fungi, there is observed first a roundish protuberance on the elium. This swelling is called the volva or wrapper, and it grally enlarges, containing in its interior what appears afterwards as agaric with its reproductive bodies. When the volva is ruptured, fully-formed agaric is seen, consisting of an upper rounded portion ed the pileus or cap (fig. 783 *c c*), supported on a stalk or stipes 783 *p*). On its under surface is situated the hymenium (ὑμὴν, nbrane), or the part where the spores are produced (fig. 783 *h*), ered at first by a thin membrane called a veil (indusium or velum), ch is ultimately ruptured; and when the rupture takes place at the e of the pileus, an annulus or ring is left on the stipes (fig. 783 *a a*). hymenium, or the part on which the organs of reproduction are ed, consists in the agaric of cellular plates, lamellæ, or gills, radiating n the centre (fig. 783 *h*). In other genera of Fungi (fig. 786) it

s. 783-787.—Figures to illustrate the natural order Fungi.

. 783.—A cluster of plants of Agaricus campestris, Mushroom, in different stages of dement. *p*, Stipe or stalk. *c c c*, Pileus, hat or cap. *v*, Velum or indusium which unites the s and stipe, and when ruptured forms the annulus or ring, *a a*. *h*, Lamellæ or gills radiating the centre, on the under surface of the pileus, and bearing the hymenium or receptacle of pores.

. 784.—Hymenium seen from above, the spores, *b*, being scattered over it in sets of four ernary).

. 785.—A small portion of the Hymenium much magnified and viewed laterally. *h*, Its composed of cells. *b*, Basidia or sporophores bearing the spores; one of these is figured ately, bearing a large number of spores. *c*, Cystidia or thecæ.

. 786.—A small portion of the pileus of Clathrus cancellatus, in the form of a sort of net- The Hymenium covers its inner surface, and is seen following the contour of the lacunæ, the net-work.

. 787.—Hymenium much more highly magnified to show the particular form of the basidia, Spores.

consists of tubes or solid columns, or fleshy or gelatinous matter. Sometimes the hymenium is on the upper surface of the fungus.—Cellular plants, often growing on decaying organic matter, generally very fugacious, and presenting various colours. They are found in all parts of the world.

1123. The following are the divisions usually recognized, as defined by Berkeley:—

1. Hymenomycetes (ὑμὴν, a membrane, and μύκης, a fungus): Hymenium naked, spores in sets of four (fig. 784 *b*), and borne on distinct sporophores (figs. 783 785).
2. Gasteromycetes (γαστὴρ, a belly): Hymenium enclosed in a membrane (peridium), spores as in section 1 (figs. 786, 787).
3. Coniomycetes (κόνις, powder): Flocci of the fruit obsolete or mere peduncles, spores single, often partitioned, and on more or less distinct sporophores
4. Hyphomycetes (ὑφάω, I weave): Thallus floccose, spores naked, often septate.
5. Ascomycetes (ἀσκὸς, a bag): Sporidia (spores) contained often in sets of eight in asci or tubes.
6. Physomycetes (φῦσα, a bladder): Thallus floccose, spores surrounded by a vesicular veil or sporangium.

Under these sections Berkeley enumerates 598 genera, including about 4,000 species. *Examples*—Agaricus, Polyporus, Hydnum, Clavaria; Phallus, Geaster, Bovista, Craterium, Nidularia; Bactridium, Torula, Uredo, Æcidium; Ceratium, Tubercularia, Botrytis, Penicillium; Helvella, Peziza, Tuber, Erysiphe, Onygena; Phycomyces, Mucor.

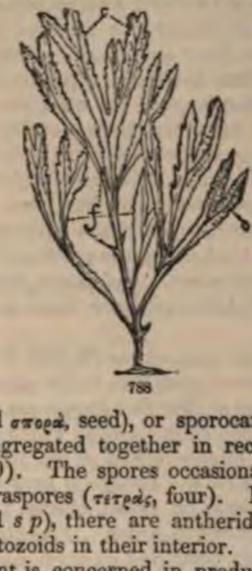
1124. The plants of this order deserve attention, whether we regard their esculent or their poisonous qualities, or the destruction which they cause by their parasitic growth. In this country the chief species eaten are *Agaricus campestris*, the common Mushroom, *Agaricus Georgii*, *Morchella esculenta* and other species of Morel, *Tuber cibarium*, Truffle. In foreign countries, as in France, Italy, Germany, and Russia, numerous Fungi are used as food, which have acted as poisons in this country. The process of cooking, as well as the climate, may have some effect in modifying their qualities. *Agaricus procerus* is eaten abroad; but a case of poisoning from it has been known to occur in Edinburgh. In Rome it is stated that the yearly average of taxed mushrooms, from 1837 to 1847, was between 60 and 80,000 pounds weight. The finest mushroom is said to be the *Agaricus Prunulus*. *Amanita muscaria* is a poisonous species, which is used as a means of intoxication in Kamtschatka. It is said to give this property to the urine of those who eat it. It is not easy to distinguish between edible and poisonous Fungi. It has been said that the latter are often highly coloured, have scales or spots on their surface, tough watery flesh, and grow in clusters on wet ground, and often in the shade; while the former are seldom highly coloured, generally white or brownish, rarely show scales or spots, have brittle flesh, and grow solitary in dry pastures, not in the shade. In some cases Fungi form a staple article of food. Darwin states that the inhabitants of Tierra del Fuego live upon a globular fungus of a bright yellow colour (*Cyttaria Darwinii*), found on the bark of the beech. Many species of *Boletus* are used as food in Western Australia, according to Drummond. *Mylitta australis* is known in Australia as Native Bread.

1125. Some Fungi are limited to certain kinds of decaying matter. Many species of *Onygena* are found only on the dung, feathers, and hoofs of particular animals. Peculiar species of *Mycoderma* are devoloped in vinegar, in yeast, and in flour. The rapidity with which Fungi sometimes grow is remarkable. Ward noticed *Phallus impudicus* shoot up three inches in the course of twenty-five minutes, and attain its full elevation of four inches in an hour and a-half. *Bovista gigantea*, in a single night, has increased from the size of a pea to that of a melon. The force also with which they expand has been shown by their raising pavements under which they had been developed. Some Fungi, as *Agaricus oreades*, *coccineus*, and *personatus*, are developed in a centrifugal manner, forming fairy rings. Certain species of *Agaricus* give out a sort of phosphorescent light. This has been remarked in *Agaricus olearius*, *Agaricus Gardneri*, and some species of Agaric from the Swan River. A similar kind of light is produced by species of *Rhizomorpha*, which occur in coal mines. *Polyporus fomentarius* forms amadou, and it, as well as *P. betulinus*, have been made into razor-straps.

1126. The diseases caused by Fungi are numerous (¶ 693-696). Blight, mildew, rust, and smut, are diseases of grain due to the attacks of Fungi. Dry-rot is owing to the presence of *Merulius lacrymans* and *vastator*, and *Polyporus destructor*, the mode of preventing which has been already alluded to (¶ 699). The disease called ergot, which attacks Rye and other grasses, is produced by the *Cordyceps purpurea* (¶ 1103). The various moulds which occur on bread, cheese, preserves, and fruits, are plants of this extensive order. *Penicillium glaucum* is one of the most common moulds, occurring on organic substances, on books, &c. A species of *Racodium* is found in low cellars, as at the London docks. Some Fungi are produced on living animals. Thus, the disease called muscardine in the silkworm is produced by *Botrytis Bassiana*. Certain wasps in the West Indies are affected by a similar disease. *Sphæria sinensis*, a celebrated Chinese drug, grows from a caterpillar; *Sphæria Robertsii* is developed on the larva of *Hepialus virescens* in New Zealand; and *Sphæria Taylori* on an Australian caterpillar. So are also *Sphæria sobolifera*, *entomorhiza*, *militaris*, and others. Particular kinds of mould sometimes grow on the mucous membrane of birds. Some mycodermatous Fungi are connected with certain cutaneous and other diseases in the human species. Thus, cellular filaments called Porrigophytes are found in the crusts of

Porrigo favosa, Mentagraphytes in those of *Mentagra* or *Sycosis menti*, and Aphthaphytes in *Aphthæ*. These are all forms of mould.

1127. Order 220.—**Algæ**, the Sea-weed Family. Cellular plants found both in salt and in fresh water. Fronds composed of variously formed, often elongated cells, which are either simple or branched filaments, continuous or articulated, separate, or combined in different ways (fig. 29) so as to constitute fronds of various kinds (fig. 788). Growth takes place by the division of cells, or by cellular prolongations, in the form of lateral branches. Reproductive organs consist of spores, which are contained in mother-cells or perispores (περὶ, around, and σπορὰ, seed), or sporocarps (καρπὸς, fruit). These are sometimes congregated together in receptacles of different sorts (figs. 788 *c c*, 789). The spores occasionally divide into 3 or 4 cells, constituting tetraspores (τετρὰς, four). In addition to spores or sporocarps (fig. 791 *s p*), there are antheridia, consisting of minute cells with spermatozoids in their interior. In some of the simplest Algæ, the whole plant is concerned in producing new individuals by division of the parent cells into 2 or 4. In others there is a union of 2 filaments, and a passage of certain granular particles (endochrome) from the one to the other, ending in the formation of the spore. This process is termed *conjugation*, and is one of great interest. It has been ob-



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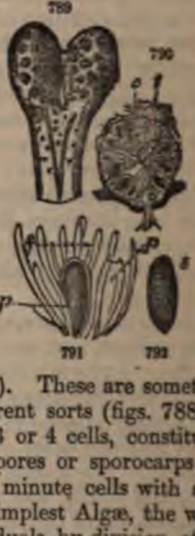

Figs. 788-792.—Frond and organs of reproduction of Fucus serratus to illustrate the natural order Algæ.

Fig. 788.—The entire plant much diminished in size. *f*, Frond composed of cells, so united as to form a flat expansion. *c c*, Conceptacles at the extremities of the frond, containing the organs of reproduction.

Fig. 789.—Extremity of the frond covered with conceptacles.

Fig 790.—Vertical section of a conceptacle, *c*, with its inner surface covered with spores (sporocarps), and paraphyses, or antheridia. *t*, The superficial cellular tissue of the frond, in which the conceptacle is buried. *o*, Foramen by which the conceptacle opens externally.

Fig. 791.—Spore, *s p*, covered with its perispore or sporocarp, *p*. *f*, Filaments or paraphyses, by some called antheridia.

Fig. 792.—Spore, *s*, separated and deprived of its perispore or outer covering.

served in some of the *Confervaceæ* and *Diatomaceæ*. In certain cases, the terminal cell of the filament is that in which a spore is formed without any conjugation, and in these cases the spore is frequently provided with ciliary processes, which exhibit for a time spontaneous movements (figs. 431-434); hence called zoospores. In the higher Algæ, the sporocarps containing 2, 4, or more reproductive cellules, are united together in conceptacles along with antheridia containing phytozoa or spermatozoids (figs. 790, 791). In *Characeæ* there are two distinct organs of reproduction.

1128. This extensive order has been divided into the following sub-orders:—

1. Characeæ: water plants formed of parallel tubes, which are sometimes encrusted with carbonate of lime; reproductive organs are of two kinds—*a*, a round red globule consisting of eight valves which enclose cells of different kinds, containing granular matter and peculiar spiral filaments or phytozoa (fig. 369); *b*, an oval nucule formed by a large central cell or spore, with five elongated cells wound spirally round it, surmounted by five teeth. Some consider the globule as an antheridium, and as equivalent to an anther. The nucule contains the germinating body. The rotation of granules takes place in the plants of the tribe (¶ 275, 276).

2. Fucaceæ, the Sea-wrack tribe: usually growing in salt water; frond consisting of cells which are often united by gelatinous matter (fig. 29), and which sometimes form a broad expansion (a membranous thallus), supported on a stalk; organs of reproduction consist of sporocarps and antheridia, contained in conceptacles opening externally (fig. 790), which are united in club-shaped expansions or receptacles, situated at the end or margins of the fronds (figs. 788, 789). In germinating, the nucleus bursts the epispore or outer covering of the spore, and sends out filamentous processes.

3. Florideæ or Ceramiaceæ: rose or purple-coloured sea-weeds, with fronds formed of a single row of articulated cells, or of several rows of cells combined into a flat expansion; organs of reproduction consist of sporocarps or perispores, intermingled with clavate filaments called antheridia. The sporocarps contain cells or spores often divided into four (tetraspores), and enclosed in conceptacles of various kinds.

4. Confervaceæ: aquatic plants, often of a green colour, consisting of one or more cells of a rounded or cylindrical form, united together so as to form an articulated or flat frond. They increase by the merismatic division of cells. Reproduction effected by spores which are formed in the interior of the cells by a change in the arrangement of the granular matter, or by the union of filaments of different plants, a process of conjugation, by which granular matter passes from one to the other. The spores are discharged by the opening of the cells, and they often have moving cilia (figs. 431-434).

5. Diatomaceæ: inhabiting still waters and moist places; fronds consisting of frustula or fragments, which are either angular or cylindrical, often siliceous and brittle (non-siliceous in Desmidieæ), united by a gelatinous sort of substance; propagated by the division of parent cells into two halves, which become more or less completely detached, and form new individuals. Conjugation also takes place in some instances, in the same way as in the Confervaceæ.

The order Algæ, exclusive of Characeæ, has been divided by Harvey as follows:—

1. Melanospermeæ: plants of an olive-green or olive-brown colour, and cellular or filamentous structure; growing in the sea. Fructification contained in definite capsules or receptacles, or in distinct sori. Seeds dark-coloured.
2. Rhodospermeæ: plants usually marine, of a rose-red, purple, or red-brown colour, leafy, cylindrical, or filamentous. Fructification usually double: the primary contained in capsules, receptacles, or immersed in the frond; secondary, when present, minute granules forming sori, or embedded in distinct receptacles. Seeds red or red-brown.
3. Chlorospermeæ: plants growing either in the sea, in fresh water, or in damp situations; either filamentous, membranaceous, or shapeless; either colourless, or (owing to the presence of an internal, granular, sporular mass) of a grass-green, very rarely purple or red colour. Fructification, green or purple sporules, either filling the frond or collected into sporidia, rarely contained in external capsules.
4. Diatomaceæ: as already defined above.

Authors enumerate 350 genera, including above 2000 species. *Examples*—Chara, Nitella; Fucus, Sargassum, Laminaria, Padina, Ectocarpus, Bryopsis; Ceramium, Delesseria, Rhodymenia, Chondrus; Conferva, Ulva, Oscillatoria, Palmella, Protococcus; Diatoma, Homœocladia, Desmidium.

1129. The plants of the order are widely distributed over the globe, being found in salt and fresh water, in moist places, as on damp rocks and stones, and the glass and pots of hothouses, and even in hot springs. Sometimes they present collectively the appearance of green slime. They derive nourishment chiefly from the medium in which they grow; and the root-like processes with which some of them are provided, seem to be merely for the purpose of fixing them. Some of the species are very gigantic, others very minute, requiring the aid of the microscope for their detection. The lowest members of the order approach very nearly to the lowest tribes of animals, and it is difficult to draw a line of demarcation. Many species now considered vegetable, such as *Corallina officinalis* and many *Diatomaceæ*, are figured as animals by Ehrenberg. There are interesting movements connected with the cells of many Algæ, such as *Oscillatoria* and *Nostoc*. Some of the species found in the ocean have conspicuous stems, which sometimes present the appearance of zones in their interior (¶ 106). Among the large-stemmed species may be noticed *Durvillea utilis* and *Lessonia fuscescens*. *Scytosiphon* (*Chorda*) *Filum* attains in the British seas a length of 30 or 40 feet, while *Macrocystis pyrifera* in the Pacific ocean reaches the length of 500 to 1,500 feet. Some of the *Laminarias* of Britain have stalks of considerable size. *Sargassum bacciferum*, the Gulf-weed, is found floating in great quantities on each side of the equator in the Atlantic, Pacific, and Indian oceans. *Protococcus nivalis* and *viridis* are said to occur in red and green snow. The red and green colours of certain lakes and seas are attributed to species of *Trichodesmium* and *Sphærozyga*. According to Dr. Joseph Hooker, *Diatomaceæ* are found in countless numbers between the parellels of 60° and 80° S., where they give a colour to the sea, and also to the icebergs floating on it. The death of these bodies in the South Arctic ocean is producing a submarine deposit, consisting entirely of the siliceous particles which entered into the composition of these plants. *Conferva crispa*, called Water-flannel, forms beds of entangled filaments on the surface of water. Species of *Tyndaridea* also occur in thick green patches. *Hydrodictyon utriculatum*, Water-net, has the appearance of a green-net, composed of filaments which enclose pentagonal and hexagonal spaces. *Achlya prolifera*, and other Confervæ, are developed occasionally on living animals, such as on the gills of the gold-fish and of trout. Certain organisms have been detected in the human stomach, which appear to belong to this order. One of these is called *Sarcinula ventriculi* by Goodsir, and was ejected by vomiting in a case of pyrosis. It consists of square cells united together in sets of four, and propagating by division. It is probably an anomalous condition of a mould-fungus.

1130. The plants of this order supply a quantity of gelatinous matter, and many of them are used for food. Kelp is obtained by the burning of Sea-weeds, and iodine is procured from them. *Sphærococcus* (*Chondrus*) *crispus*, Carrageen or Irish Moss, supplies a nutritious article of diet. *Rhodymenia palmata*, Dulse, *Alaria esculenta*, *Iridæa edulis*, young plants of *Laminaria digitata* and *saccharina*, Tangle, as well as various species of *Porphyra*, Laver, and *Ulva*, Green Laver, are esculent. The edible swallows'-nests of the East are said to be formed of a species of *Galidium*. *Sphærococcus cartilagineus*, var. *setaceus*, is used in China as a substitute for these nests. Agar-agar is a sea-weed of a similar kind. *Nostoc edule* is used in China as an article of food. The use of burnt sea-weed, in cases of scrofulous swellings, has been superseded by the discovery of iodine, the active ingredient. *Plocaria* (*Gigartina*) *Helminthocorton*, under the name of Corsican Moss, was formerly used as a vermifuge. The *Charas* have frequently a peculiarly fetid odour, and their presence is said to give rise to malaria. Occasionally they communicate their odour to the water of reservoirs, and render it unpleasant. It is of importance for Water Companies to see that Charas do not exist in the streams which supply the water for their reservoirs.

PART III.

GEOGRAPHICAL BOTANY, OR THE DISTRIBUTION OF PLANTS OVER THE GLOBE.

1131. THIS department of Botany treats of the manner in which plants are affected by climate and station, and endeavours to investigate the conditions under which particular families, or species of plants, are confined to certain zones of latitude and altitude. It is a subject of great interest, and one which cannot be prosecuted with success until the vegetation of the globe is more fully known. So long as there are vast tracts of continents unexplored by botanical travellers, the facts upon which Botanical Geography is founded must be imperfect.

I.—EPIRRHEOLOGY, OR THE INFLUENCE OF VARIOUS EXTERNAL AGENTS ON PLANTS.

1132. It is a matter of common observation, that the localities and soils in which plants grow vary much. Thus, some species grow in the shade, while others thrive best in full exposure to light; some grow in mountainous or alpine districts, while others prefer the plains; some are found in dry, others in marshy places; some are submersed in lakes or in the sea; while others live on muddy banks, or on sandy shores. The plants growing on a granitic or micaceous soil differ frequently from those found on trap, limestone, or sandstone. It is equally well known that climate exercises a powerful influence on vegetation, modifying the Floras in different regions of the globe. Some plants are fitted to bear the rigour and duration of an arctic winter, with a moderate summer heat, others require the heat and light of the torrid zone; and between these two extremes, there are all varieties of gradation. Thus vegetation extends over the whole globe, from one pole to the other—from the summit of the highest mountains to the bosom of the ocean. There are, notwithstanding this general diffusion of vegetable structures, a few spots in which their traces have not been detected. Among such districts may be mentioned the hot sands of Africa, and some of the Antarctic Islands. In other districts their number and species are limited to a few. Each zone may be said to have its own peculiar vegetable features, the number of species being found to increase as we approach the equator, and to decrease as we retire from it. Palms, Bananas, Tree Ferns, and Orchideous Epiphytes, are chiefly confined to the tropics; Cruciferous and Umbelliferous plants are found in temperate regions; some Coniferous and Amentaceous plants flourish in more northern countries, while Saxifrages and Lichens extend to the arctic regions. In warm regions are found those fruits which are so necessary for the well-being of the inhabitants; in temperate climates chiefly, occur the cereal grains for the food of man, and the green pastures for the nourishment of cattle; and in the arctic regions, the Lichen, on which the reindeer feeds, grows luxuriantly.

1133. The number of known species of plants amounts to about 100,000. The following is an estimate of the known species of plants on the globe at different dates:—

Linnæus	1753	5,323	Phanerog.	615	Cryptog.	5,938
Persoon	1807	19,949	—	6,000	—	25,949
Steudel	1824	39,684	—	10,965	—	50,649
Steudel	1841	78,000	—	13,000	—	91,000
Steudel	1844	80,000	—	15,000	—	95,000

In 1846, Lindley gave the following estimate of known genera and species:—

Thallogens	939	Genera,	8,394	Species.
Acrogens	310	—	4,086	—
Rhizogens	21	—	53	—
Endogens	1,420	—	13,684	—
Dictyogens	17	—	268	—
Gymnogens	37	—	210	—
Exogens	6,191	—	66,225	—
Total	8,935		92,920	

Much yet remains to be done in regard to the Floras of India, China, Africa, New Holland, and South America. Meyen conjectures that the total vegetation of the globe may be about 200,000 species.

1134. The distribution of species over different quarters of the globe is regulated by various external agents, the study of which is termed Epirrheology (ἐπιῤῥέω, I influence). These agents are chiefly temperature and moisture, and the nature of the soil. The effects produced on plants by increase or decrease of light, and by changes in the state of the atmosphere, have not been sufficiently determined.

1.—EFFECTS OF TEMPERATURE.

1135. The effects of this agent must be considered both as regards its latitudinal and its altitudinal ranges. In proceeding from the equator to the poles, or in ascending from the surface of the ocean to the summit of a lofty mountain, there is a gradual decrease of temperature, and, at the same time, marked changes in the nature of the vegetation. The scale of atmospherical temperature serves as a scale for the progress of vegetation. As regards the latitudinal distribution of heat, the globe has been divided into eight regions, four northern and four southern—viz., a tropical region, from the equator to the limits of the tropics in each hemisphere; subtropical, between this and 40° of latitude; temperate, between 40° and 60° of latitude; arctic and antarctic, beyond 60° of latitude.

1136. Each species of plant is adapted to thrive best between certain limits of temperature. These limits do not necessarily coincide with any definite parallels of latitude; for it is well known that the climate of different places in the same latitude is very different. It is of importance, therefore, to ascertain the mean temperature of the year, or rather of different seasons. By drawing lines through different places where the mean annual temperature is the same, Humboldt has established a series of isothermal (ἴσος, equal, and θέρμη, heat,) lines intersecting the parallels of latitude. These lines run in curves, which rise in their course from the eastern coast of America towards western Europe, and sink towards the south in the interior of the continent,—and that so quickly, that Scotland lies in the same isothermal line as Poland, and England as Hungary. It is clear, therefore, that the isothermal lines in the higher latitudes do not, by any means, correspond with the parallels of latitude. At the equator, however, these lines coincide more nearly. Much depends upon the temperature of the different seasons. Thus, a place which has a very cold winter, and a very warm summer, may be in the same isothermal line with one in which the temperature of both these seasons is moderate, and plants which succeed well in the one may not grow in the other. Cherry-laurels and other Evergreens, which grow well in the open air in England, will not stand the winter of places on the continent in the same isothermal line. It is necessary, in determining the geographical distribution of plants, to take into account the mean summer and the mean winter heat, and, better still, the mean monthly temperature. The distribution of temperature among the different months of the year is of importance, especially in reference to the heat and duration of the summer months; for many plants protected by a covering of snow, are enabled to brave rigorous winters, provided the summer be hot enough, and of sufficient duration. Lines passing through places having the same mean summer temperature are called isotheral (ἴσος, equal, and θέρος, summer); those passing through places with an equal mean winter temperature, are isocheimonal (χειμών, winter). The isocheimonal lines in the interior of continents bend considerably towards the south. The isotheral lines bend to the north, but in the interior of continents they approach the parallels of latitude. Many circumstances conspire to influence the temperature of countries. Insular and coast climates are more equable, from the effect of the sea in preventing the atmosphere from being much heated during the day, and much cooled during night. In the interior of vast continents the extremes of temperature are often great. Winds have a powerful effect on climate. In China, the north-east monsoon brings great cold in February. The state of a country as regards forests, has a decided effect on the temperature. In different quarters, the nature of the exposure, also, whether to the east or west, north or south, and the intervention of elevated ranges of mountains, materially affect the temperature.

1137. Temperature, in its hypsometrical (ὕψος, altitude, and μέτρον, measure,) relation, or as regards its altitudinal range, requires to be considered. In ascending into the atmosphere, a decrease of temperature is observed, which varies in its amount at different stages of ascent. The following table shows the temperature at different heights in the equatorial and temperate zones:—

Height in feet.	Equat. Zone. Lat. 0°—10°		Temp. Zone. Lat. 45°—47°
0	81°·50 F.	Mean.	53°·60 F.
3,197	71 ·24	......	41 ·00
6,394	64 ·40	......	31 ·64
9,591	57 ·54	......	23 ·36
12,789	44 ·60		
15,985	37 ·70		

Taking an average, it may be said that there is a fall of 1° in the thermometer for every 340 feet of ascent. Prof. Forbes states that 549·5 feet of ascent give a difference of 1° of the thermometer in the boiling point of water. The elevation at which constant frost takes place is called the snow-line or line of perpetual congelation. Its limit does not exactly correspond with the height at which the temperature is equal to 32° F. The following table gives the height of the snow-line (in feet) at different latitudes:—

Lat.	Height of Snow Line.	Lat.	Height of Snow Line.
0	15,207	50	6,334
5	15,095	55	5,034
10	14,764	60	3,818
15	14,220	65	2,722
20	13,278	70	1,778
25	12,557	75	1,016
30	11,484	80	457
35	10,287	85	117
40	9,001	90	0
45	7,671		

The decrease of temperature on lofty mountains regulates, in a great measure, the nature of the plants which grow at different heights. The same changes take place as have been shown to occur in proceeding from the equator to the poles. The following observations made on the growth of certain trees on the Grimsel, show the relation between height and latitude :—

	Lat.	On the Grimsel.
Beech, which extends to	60°	grows about the height of 3000 feet.
Oak	61°	2600 —
Fruit Trees	63°	3400 —
Hazel	64°	
Norway Spruce	67° 40′	5000 —
Scotch Fir	70°	6000 —
Birch	70° 40′	6400 —

2.—Effects of Moisture.

1138. The quantity of moisture in the air has a decided effect on the distribution of plants. Nothing checks vegetation more than extreme dryness. Hence the barrenness of those hot sandy deserts, which exhibit only an arid waste, without a single blade of grass to relieve the eye of the weary traveller. In warm and dry climates, succulent plants occur, with hard epidermal coverings, capable of resisting the effects of evaporation and transpiration. Among these may be noticed Cactaceæ, Mesembryaceæ, Euphorbias, and some of the Aloe tribe. In the districts of Australia, where a dry climate prevails, many plants, such as Proteas, Banksias, and leafless Acacias, have hard and dry foliage, capable of enduring much drought without injury. In warm climates, the effect of the dry season on vegetation is very remarkable. This season may be said to correspond with our winters. In some parts of South America, where no rain falls for eight months of the year, the leaves during the dry season fall, buds are developed in their axils, and it is only when the wet season arrives that the trees become clothed with verdure, and the herbage appears. Forests appear to keep up the humidity of the atmosphere in a country, and thus have a powerful influence on the climate.

3.—Effects of Soil, Light, and other Agents.

1139. The physical localities in which plants grow vary considerably. These variations are connected with the dryness and moisture of the soil, as well as with its mechanical and chemical composition. Some plants are fitted to grow in water, others in marshes; some grow in peaty soil, others in sandy soil. Thurmann has endeavoured to show that the nature of the soil, whether siliceous, clayey, calcareous, or saline, has an effect in modifying the vegetation. Prof. E. Forbes states, that, in Lycia, he could easily distinguish the serpentine from the limestone, not merely by their geological characters, but also by the disposition of the arborescent vegetation. On the serpentine, usually pines only grew, and never in thick forest masses, but scattered; whereas the limestone bore thick clustered oaks and a luxuriant underwood, with now and then clumps of lofty pines. In the low countries near the sea, the serpentine was marked by Senecio squalidus, a little Erophila, and Cheilanthes odora; while on the limestone, Acrostichum lanuginosum was a conspicuous fern.

The following is a division of plants according to the botanical stations or physical localities in which they grow, whether placed there by nature or by art. :—

A.—*Plants growing in Water, whether Salt or Fresh.*

1. Marine Plants, such as Sea-weeds, Lavers, &c., which are either buried in the ocean, or float on its surface: also, such plants as *Ruppia* and *Zostera*. In the Sargasso Sea there are floating meadows of *Sargassum bacciferum*, gulf-weed. This sea extends from 22° to 36° north lat., and from 25° to 45° west long. from Greenwich, and extends over 40,000 square miles.

2. Maritime or saline plants. These are plants which grow on the border of the sea, or of salt lakes, and require salt for nourishment, as *Salicornia*, glasswort, *Salsola*, saltwort, *Anabasis*. Such plants are often called Halophytes (ἅλς, salt, and φυτὸν, a plant). Under this head may be included littoral and shore plants, such as *Armeria*, sea-pink, *Glaux*, and *Samolus*.

3. Aquatic plants, growing in fresh water, either stagnant or running; as *Sagittaria*, arrowhead, *Nymphæa*, water-lily, *Potamogeton*, pondweed, *Subularia*, awlwort, *Utricularia*, bladderwort, *Stratiotes*, water-soldier, *Lemna*, duckweed, *Pistia*, *Confervæ*, *Oscillatoriæ*, and *Ranunculus fluviatilis*. Some of these root in the soil, and appear above the surface of the water; others root in the soil and remain submersed; while a few swim freely on the surface without rooting below.

4. Amphibious plants, living in ground which is generally submerged, but occasionally dry, as *Ranunculus aquatilis* and *sceleratus*, *Polygonum amphibium*, *Nasturtium amphibium*. The form of the plants varies according to the degree of moisture. Some of these, as *Limosella aquatica*, grow in places which are inundated at certain periods of the year; others, such as *Rhizophoras* (mangroves), and *Avicennias*, form forests at the mouths of muddy rivers in tropical countries.

B.—*Land Plants which root in the Earth and Grow in the Atmosphere.*

5. Sand plants; as *Carex arenaria*, *Ammophila arenaria*, *Elymus arenarius*, and *Calamagrostis arenaria*, which tend to fix the loose sand, *Plantago arenaria*, *Herniaria glabra*, *Sedum acre*.

6. Chalk plants; plants growing in calcareous and cretaceous soils, as some species of *Ophrys*, *Orchis*, and *Cypripedium*.

7. Meadow and pasture plants; as some species of *Lotus*, bird's-foot trefoil, a great number of grasses and trefoils, the daisy, dandelion, and buttercups.

8. Plants found in cultivated ground. In this division are included many plants which have been introduced by man along with grain; as *Centaurea Cyanus*, corn blue-bottle, *Sinapis arvensis*, common wild mustard. *Agrostemma*, corn-cockle, several species of *Veronica* and *Euphorbia*, *Lolium temulentum*, *Convolvulus arvensis*, *Cichorium Intybus*; also plants growing in fallow ground, as *Rumex Acetosella*, *Carduus*

nutans, *Echium vulgare*, *Artemisia campestris*, and *Androsace septentrionalis*. In this division, garden weeds are included; such as Groundsel, Chickweed, *Lamium amplexicaule*, *Chenopodium album*, and *urbicum*.

9. Rock or wall plants; Saxifrages, Wall-flower, *Linaria Cymbalaria*, *Draba muralis*, species of *Hieracium* and *Sedum*, *Asplenium Ruta muraria*, and some lichens and mosses.

10. Plants found on rubbish heaps, especially connected with old buildings. Some of these seem to select the habitations of man and animals, on account of certain nitrogenous and inorganic matters, which enter into their composition. Among them may be noticed, Nettles, Docks, Borage, Henbane, *Xanthium*. Here, also, have been placed some plants immediately connected with the habitation of man, such as *Racodium cellare*, a fungus found on wine casks, *Conferva fenestralis*, an alga produced on window-panes, and *Conferva dendrita*, one developed on paper. Some plants, as *Sempervivum tectorum*, select the roofs of houses.

11. Plants growing in vegetable mould; such as bog-plants, or those growing on wet soil, so soft that it yields to the foot, but rises again; and marsh plants, growing in wet soil, which sinks under the foot and does not rise. To the former class belong such plants as *Pinguicula alpina* and *Primula farinosa*; to the latter, such as *Menyanthes*, *Comarum*, *Bidens cernua*.

12. Forest plants, including trees which live in society, as the Oak, the Beech, Firs, &c., and the plants which grow under their shelter, as the greater part of the European Orchises, some species of *Carex* and *Orobanche*. Some plants especially grow in pine and fir-woods, as *Linnæa borealis*, and some Pyrolas.

13. Plants of sterile places, found in barren tracts, by roadsides. This is a heterogeneous class, and contains many plants of uncertain characters. Under it are included the plants of uncultivated grounds, as those found in moors, where *Calluna vulgaris*, common heather and various heaths, Juniper, *Andromeda*, and some species of *Polytrichum* occur.

14. Plants of the thickets or hedges, comprehending the small shrubs which constitute the hedge or thicket, as the Hawthorn and Sweet-briar; and the herbaceous plants which grow at the foot of these shrubs, as *Adoxa*, Wood-sorrel, Violets; and those which climb among their numerous branches, as Bryony, Black Bryony, Honeysucke, Traveller's Joy, and some species of *Lathyrus*.

15. Plants of the mountains, which De Candolle proposes to divide into two sections: 1. Those which grow in alpine mountains, the summits of which are covered with perpetual snow, and where, during the heat of summer, there is a continued and abundant flow of moisture, as numerous Saxifrages, Gentians, Primroses, and Rhododendrons. 2. Those inhabiting mountains on which the snow disappears during summer, as several species of Snap-dragon, among others the Alpine Snap-dragon, Umbelliferous plants, chiefly belonging to the genus *Seseli*, meadow Saxifrage, Labiate plants, &c.

C.—*Plants Growing in Special Localities.*

16. Parasitic plants, which derive their nourishment from other vegetables, and which, consequently, may be found in all the preceding situations; as the Mistleto, species of *Orobanche*, *Cuscuta*, (Dodder), *Loranthus*, *Rafflesia*, and numerous Fungi.

17. Pseudo-parasitic plants, or Epiphytes, which live upon dead vegetables, as Lichens, Mosses, &c. or upon the bark of living vegetables, but do not derive much nourishment from them, as *Epidendrum*, *Aerides*, and other Orchids, as well as *Tillandsia*, *Bromelia*, *Pothos*, and other air-plants.

18. Subterranean plants, or those which live under ground, or in mines and caves, almost entirely excluded from the light, as *Byssus*, Truffles, and some other Cryptogamic plants.

19. Plants which vegetate in hot springs, the temperature of which ranges from 80° to 150° of Fahrenheit's thermometer; as *Vitex Agnus-castus*, and several Cryptogamous plants, as *Ulva thermalis*, the hot-spring Laver.

20. Plants which are developed in artificial infusions or liquors, as various kinds of *Mucor*, causing mouldiness.

21. Plants growing on living animals; as species of *Sphæria* and *Sarcinula* and various other Fungi and Algæ.

22. Plants growing on certain kinds of decaying animal matter; such as species of *Onygena*, found on the hoofs of horses, feathers of birds, &c., some species of Fungi, which grow only on the dung of animals, and certain species of *Splachnum*.

1140. Light is an agent that has a powerful influence on plants, as regards their vigour, irritability, secretions, and colour. Hence, in those regions where the light is intense, the vegetation presents certain peculiarities. The luxuriance and greenness of the leaves, the nature of the woody matter deposited, of the fruit produced, and of the secretions formed, are all influenced in some degree by the intensity of the sun's rays. Little is known in regard to the effects of increased or diminished atmospheric pressure on plants. Humboldt believed that vegetation was influenced by the amount of atmospheric pressure. Further research has not corroborated his suppositions. The effects of the atmosphere have been studied chiefly as regards dryness and moisture, and the mixture of certain gases with it, especially in the vicinity of manufacturing towns (¶ 297).

1141. The effects of climate and season on the leafing, flowering, and fruiting of plants, may be seen in the case of some species which are found distributed over various countries in Europe. Berghaus has made an extensive series of observations on the subject. The Lilac (*Syringa vulgaris*), according to him, unfolds its leaves at Naples, in latitude 41°, during the first half of the month of January; near Paris, in latitude 49°, on the 12th March. The Elder unfolds its leaves

At Naples	January 1-15.
At Paris	February 14.
In England	March 8.
At Upsal	March 1-8.

The Beech unfolds its leaves

At Naples	End of March.
In England	1st May.
At Upsal	Beginning of May.

In regard to flowering, Berghaus states, that in the middle latitudes of Europe and North America, it is generally four days later for each degree of latitude towards the north. The same plants flower at Zurich 6 days later than at Parma; at Tubingen, 13 days later; at Jena, 17; at Berlin, 25; at Hamburgh, 33; at Greifswald, 36; and at Christiania, no less than 52 days later than at Parma. In the Berlin district, an elevation of 1,000 feet renders vegetation 10 to 14 days later: so also in regard to fruiting. The wheat harvest begins

At Naples	In June.
In Central Germany	July.
In the South of England	August

Ripe Cherries are to be had

At Naples	First days of May.
At Paris	End of June.
In Central Germany	do.
In the South of England	22d July.

II.—Dissemination of Plants.

1.—Agents employed in their Dissemination.

1142. Some plants are disseminated generally over the globe, while others are confined within narrow limits. Some of the common weeds in Britain, such as Chickweed, Shepherd's-purse, and Groundsel, are found at the southern extremity of South America. Lemna minor and trisulca, Convolvulus sepium, Phragmites communis, Cladium, Mariscus, Scirpus lacustris, Juncus effusus, and Solanum nigrum, are stated by Meyen to be common to Great Britain and New Holland. Nasturtium officinale, and Samolus Valerandi, are very extensively diffused, and they may be reckoned true cosmopolites. They are both natives of Europe, and they occur, the former near Rio Janeiro, the latter at St. Vincent. The lower the degree of development, the greater seems to be the range. Some Cryptogamic plants, as Lecanora subfusca, are found all over the world. Man has been instrumental in diffusing widely culinary vegetables, such as the potato, and the cereal grains, as well as many other plants useful for food and manufacture. Corn plants, such as Barley, Oats, Rye, Wheat, Spelt, Rice, Maize, and Millet, are so generally cultivated over the globe, that almost all trace is lost of their native country. They can arrive at perfection in a great variety of circumstances, and they have thus probably a wider geographical range than any other kind of plant. As regards these plants, the globe may be divided into five grand regions—the region of Rice, which may be said to support the greatest number of the human race; the region of Maize; of Wheat; of Rye; and lastly, of Barley and Oats. The first three are the most extensive, and Maize has the greatest range of temperature. The grains extending farthest north in Europe are Barley and Oats. Rye is the next, and is the prevailing grain in Sweden and Norway, and all the lands bordering on the Baltic, the north of Germany, and part of Siberia. Wheat follows Rye; it is cultivated in the middle and south of France, England, part of Scotland, part of Germany, Hungary, Crimea, and the Caucasus. We next come to a district where wheat still abounds, but no longer exclusively furnishes bread, rice and maize becoming frequent. To this zone belong Portugal, Spain, part of France, Italy and Greece, Persia, Northern India, Arabia, Egypt, the Canary islands, &c. Wheat can be reared wherever the mean temperature of the whole year is not under 37° or 39° F., and the mean summer heat, for a period of at least three or four months, is above 55°. It succeeds best on the limits of the subtropical region. In the Scandinavian Peninsula, the cultivation of Barley extends to 70° north latitude, Rye to 67°, and Oats to 65°. The cultivation of Rice prevails in Eastern and Southern Asia, and it is a common article of subsistence in various countries bordering on the Mediterranean. Maize succeeds best in the hottest and dampest parts of tropical climates. It may be reared as far as 40° north and south latitude on the American continent on the western side, while in Europe it can grow even to 50° or 52° of latitude. It is now cultivated in all regions in the tropical and temperate zones, which are colonized by Europeans. Millet of different kinds is met with in the hottest parts of Africa, in the south of Europe, in Asia Minor, and in the East Indies. Henslow gives the following table to show the range of Wheat and Barley, and the mean temperature required for them:—

Lat.		Winter Mean.	Summer Mean.	Annual Mean	
62½	Feroe	39°	51°	45°	Barley.
70	Lapland	22	46	33	
67½	Russia	9	46	32	
57½	Siberia	0	60	32	
58	Scotland	36	57	46	Wheat.
64	Norway	28	59	39	
62	Sweden	23	59	39	
60½	Russia	15	60	37	
30	Cairo	57	88	72	
22	Macao	64	82	73	
22	Rio Janeiro	68	78	74	
23	Havannah	71	82	77	
21	Bourbon	71	80	77	

Winds, water, and animals, are also instrumental in disseminating plants. Many seeds with winged and feathery appendages are easily wafted about; others are carried by rivers and streams, and some can be transported by the ocean currents to a great distance, with their germinating powers unimpaired.

2.—General and Endemic Distribution of Plants.

1143. While some plants are generally diffused, it is found that the different quarters of the globe are each characterized by more or less distinct floras. Europe, Asia, Africa, North America, South America, and Australasia, may be regarded as separate provinces of the vegetable kingdom, possessing species, genera, and families of plants, which give to each division its distinctive features. Humboldt and Bonpland, in their travels in equinoctial America, did not see an exogenous plant which was found equally in the New and the Old World; the only plants which they discovered common to both being some grasses and sedges. Among 4,160 species met with in New Holland by Brown, 166 only were to be found in Europe.

1144. Some plants live in society, occupying exclusively large tracts of ground, from which they banish all other vegetables. These are called by Humboldt *Social* plants. They give a peculiar feature to the countries and districts in which they grow. To this class belong many species of Seaweed in the ocean; Cladonias and Mosses in the waste levels of Northern Asia; Grasses (Bamboos), and some Cactuses, Mangroves, and Avicennias in tropical countries; Ferns in the South Sea Islands; Banksia speciosa in New Holland; Cinchonas in certain parts of South America; Coniferous trees and Birches in the Baltic and Siberian plains.

1145. Some plants are very much restricted in their distribution over the globe; a few are confined to single localities, while others have a limited longitudinal range. The species of the genus Erica, Heath, which extend from northern regions to the Cape of Good Hope, are scattered over a surface very narrow compared to its length; in other words, while their latitudinal range is great, their longitudinal range is very much restricted. Calceolarias occur chiefly on the western side of the Cordilleras of Chili. Lobelia Dortmanna is found principally in the western countries of Europe. Camellias are also limited in longitudinal direction, so also Phalangium bicolor, and Raymondia pyrenaica. Arbutus Unedo, Erica mediterranea, and Menziesia polifolia, whose chief seat is in the Pyrenees and the mountains of Asturias, migrate in a north-westerly direction, and appear in Ireland. It is said that Azaleas, Rhododendrons, Magnolias, Vacciniums, Actæas, and Oaks, which form prevailing genera on the east of the Rocky Mountains, scarcely appear on the western side. Epacridaceæ are confined to New Holland; Cinnamon, Cloves, and Nutmeg, are the produce of the Indian Archipelago; Gentians and Saxifrages form a characteristic feature of the European Alps; Bejarias and Cinchonas of the Peruvian Cordilleras; Schizanthuses of Chili; Polemoniaceæ of California and Oregon; yellow and brown Papilionaceæ of Australasia; Disa grandiflora is a rare orchid peculiar to Table Mountain at the Cape of Good Hope; and Pringlea antiscorbutica is a cruciferous plant peculiar to Kerguelens-land. It is said that Origanum Tournefortii is found only in a small island in the Grecian Archipelago. The vegetation of islands removed from continents presents often peculiar features, the ocean acting as a barrier to the dissemination of plants. The island of St. Helena was originally inhabited by a most peculiar vegetation, although its productions now are completely changed by the destruction occasioned by cattle, and by the introduction of European and other plants, especially fruit trees. Such may also be said of the plants found in the Sandwich Islands, the Society Islands, and the Canaries. The island of Madeira has 672 Phanerogamous plants, of which 85 are peculiar to it.

8.—Conjectures as to the Mode in which the Earth was Originally Clothed with Plants.

1146. It is an interesting question to determine the mode in which the various species and tribes of plants were originally scattered over the globe. Various hypotheses have been advanced on the subject. Linnæus entertained the opinion, that there was at first only one primitive centre of vegetation, from which plants were distributed over the globe. Some, avoiding all discussions and difficulties, suppose that plants were produced at first in the localities where they are now seen vegetating. Others think that each species of plant originated in, and was diffused from, a single primitive centre, and that there were numerous such centres situated in different parts of the world, each centre being the seat of a particular number of species; they thus admit great vegetable migrations similar to those of the human races. Those who adopt the latter view, recognize in the distribution of plants some of the last revolutions of our planet, and the action of numerous and varied forces which impede or favour the dissemination of vegetables in the present day. They endeavour to ascertain the primitive flora of countries, and to trace the vegetable migrations which have taken place. Daubeny says, that analogy favours the supposition that each species of plant was originally formed in some particular locality, whence it spread itself gradually over a certain area, rather than that the earth was at once, by the fiat of the Almighty, covered with vegetation in the manner we at present behold it. The human race arose from a single pair, and the distribution of plants and animals over a certain definite area, would seem to imply that the same was the general law. Analogy would lead us to believe, that the extension of species over the earth originally took place on the same plan on which it is conducted at present, when a new island starts up in the midst of the ocean, produced either by a coral reef or a volcano. In these cases the whole surface is not at once overspread with plants, but a gradual progress of vegetation is traced from the accidental introduction of a single seed, perhaps of each species, wafted by winds, or floated by the currents. The remarkable limitation of certain species to single spots on the globe, seems to favour the supposition of specific centres. Professor E. Forbes says, the hypothesis of the descent of all the individuals of a species, either from a first pair or from a single individual, and the consequent theory of specific centres being assumed, the isolation of assemblages of individuals from their centres, and the existence of *endemic* or very local plants, remain to be accounted for. Natural transport, the agency of the sea, rivers, and winds, and carriage by animals, or through the agency of man, are insufficient means in the majority of cases. It is usual to say, that the presence of many plants is determined by soil or climate, as the case may be; but if such plants be found in areas disconnected from their centres by considerable intervals, some other cause than the mere influence of soil or climate must be sought to account for their presence. This cause he proposes to seek in an ancient connection of the outposts or isolated areas with the original centres, and the subsequent isolation of the former through geological changes and events, especially those dependent on the elevation and depression of land. Selecting the flora of the British islands for a first illustration of this view, Professor Forbes calls attention to the fact, well known to botanists, of certain species of flowering plants being found indigenous in portions of that area, at a great distance from the nearest assemblages of individuals of the same species in countries beyond it. Thus, many plants peculiar in the British flora to the west of Ireland, have the nearest portion of their specific centres in the north-west of Spain; others, confined with us to the south-west promontory of England, are, beyond our shores, found in the Channel Isles and the opposite coast of France; the vegetation of the south-east of England is that of the opposite part of the continent; and the Alpine vegetation of Wales and the Scotch Highlands is intimately related to that of the Norwegian Alps. The great mass of the British flora has its most intimate relations with that of Germany. He believes, therefore, that these isolated outposts were formerly connected together by chains of land, and that they have been separated by certain geological convulsions. Islands may be considered as the remains of mountain chains, part of the flora of which they still exhibit, and the further they are from continents, the more likely are the plants to be peculiar.

1147. All the vegetable productions of the globe are distributed according to harmonious laws, which are by no means fully developed. The greater number of families is distributed over the whole globe; individual representatives of the groups appearing in different regions. The regions of the globe, as regards their vegetable productions, are related either in the families, the genera, or the species of plants which they produce. By *families*, Hinds remarks, the most distant or general resemblances are established, constituting *analogy*. One family may occupy the place of another in certain regions. Thus, the Mesembryaceæ of South Africa are represented in America by Cactaceæ; and in the south of Europe, only by a few species of Sempervivum and Sedum. By *genera*, a closer approximation is established—that of *affinity*. The Cistuses of Spain and Portugal are represented by the

Helianthemum of the north of Europe; and the genera of Abies and Pinus, in arctic and temperate regions, have their representatives in the genera Araucaria, Ephedra, and Dammara of the south. By *species* again, the most perfect accordance of characters or *identity* is established.

1148. Meyen states, that the species of a genus, and genera, and natural orders, proceed from a point, and range themselves round it in concentric circles, or spread out from it like rays in all directions; or are distributed in belts of greater or less breadth, which are parallel to the meridians, or to the parallels of latitude. A genus or family predominates in certain regions, and attains its maximum there, while in others it is at its minimum. Hence, regions are distinguished by the names of plants which attain their maximum there. Palmæ, Musaceæ, Piperaceæ, and Scitamineæ, attain their maximum in the torrid zone, although representatives of them extend to high latitudes, or to the temperate zone. Thus, the Palm called Chamærops humilis is found in 49° north latitude. The Ericaceæ of the old world have their maximum in the south of Africa. A single form, Calluna vulgaris, common Heather, is predominant in the north; and a shrubby species, Erica arborea, represents the order in the south of Europe. Acacias attain their maximum in New Holland, while Acacia heterophylla represents the family in the Sandwich Islands. The Lauraceæ of the tropics have Laurus nobilis as their representative in Europe.

4.—DISTRIBUTION OF PLANTS CONSIDERED PHYSIOGNOMICALLY AND STATISTICALLY.

1149. The distribution of plants over the globe may be considered either *Physiognomically*, as regards the prevalence of certain vegetable forms which give a general character to the landscape of a country; or *Statistically*, as regards the numerical proportion which different groups bear to each other, or to the whole known plants.

1150. **Physiognomy of Vegetation.**—In prosecuting this department of botanical geography, it is necessary to specify those vegetable forms which give a character to the landscape. This has been done more especially by Meyen, who gives the following series:—

1. Gramineous or Grassy Form. This is illustrated in northern countries by meadows and pastures. The cereal grains also have a great influence on the aspect of countries. Under this form are included Cyperaceæ, Restiaceæ, and Juncaceæ. In the torrid zone some arborescent forms occur, as Bamboo; and along with these are associated Sugar-cane and Rice. Barley is an extra-tropical form, while Carex extends to cold regions.

2. Scitamineous Form. This includes the Ginger, Arrow-root, and Plantain family, some of which attain a large size. They contribute to give a character to the torrid zone.

3. Pandanus or Screw-pine Form. A tropical form illustrated by Screw-pines and Dracænas.

4. Pine-apple Form. Illustrated by the Bromeliaceæ of warm climes

5. The Agave or American Aloe Form. Chiefly tropical and subtropical.
6. The Palm Form. Under this are included also the Cycadaceous family. They give a character to the hotter regions of the globe. Some of the Palms are social, as the Date and Coco-nut. Chamærops humilis represents this form in Europe.
7. Filical or Fern Form. True Ferns, in an especial manner, affect the landscape in tropical and warm regions.
8. Mimosa Form. This includes Leguminous plants in general. The finely cut foliage of some has a resemblance to Ferns. Modifications of this form occur both in warm and cold regions. Acacias in New Holland give a peculiar feature to the landscape.
9. Coniferous Form. The Abietineæ are characteristic of northern regions, and the Cupressineæ of southern.
10. The Protea, Epacris, and Erica Forms. These forms supply the place of Coniferæ in the southern hemisphere. The Protea and Epacris forms occurring in Australasia, and the Erica form at the Cape of Good Hope.
11. Myrtle Form. Some of these, such as Melaleuca and Eucalyptus, characterize New Holland scenery; others, as Guavas, are tropical.
12. Forms of Dicotyledonous trees. Some with broad and tender leaves, as Birch, Alder, Poplar, Oak, Lime, Elm, Beech, and Horse-chestnut, giving a character to the physiognomy of the colder half of temperate climates; while others, with thick, leathery, and showy leaves, as Olives and Laurels, are characteristic of warmer climates; and a third division, with large, beautiful leaves, Cecropia, Artocarpus, and Astrapæa, abound in the hottest climates.
13. Cactus Form. This form is developed chiefly in America, especially in Brazil.
14. Form of Succulent plants. Seen in the Mesembryaceæ of South Africa.
15. Lily Form. This includes Liliaceæ, Amaryllidaceæ, and Iridaceæ. Modifications of this form occur in warm and temperate climates.
16. Forms of Lianas or Climbing-plants. These forms are chiefly tropical, and are illustrated by Passion-flowers, Paullinias, Aristolochias, and Bauhinias.
17. Pothos Form. This is a tropical form, and is illustrated by various species of Araceæ.
18. Orchideous Form. This is seen in the splendid Epiphytes of warm climates. Terrestrial species chiefly occur in cold zones.
19. The Moss Form.
20. The Lichen Form. Both these forms characterize cold regions chiefly.

Besides the forms of plants, it is found that the prevalent colours sometimes give a character to the vegetation. White or pale-coloured flowers are said to be more abundant in northern latitudes than in the tropics, and in alpine situations they are of more frequent occurrence than in the plains. The xanthic series of colours, Hinds states, is abundant within the tropics in the autumn, on the plains over the mountains. The flowers of the cyanic series, especially intense blues and violets, delight in the clear skies of subtropical regions. Hinds gives the following tabular view of the relative proportion of colours:

	Cyanic.	Xanthic.	White.
Central America	12	30	
Sandwich Islands	12	31	7
Alashka	26	13	11
California	25	19	6
New Guinea	12	23	15
Hong-Kong	13	27	10

Geyer says, that vivid colours mark the basaltic plains of Upper Oregon; blue and purple, eastward; scarlet with golden-yellow, westward; glaucous green reigns in the herbage over the plains; deep saturated green in the valleys.

1151. **Statistics of Vegetation.**—The number of known vegetable families differs in different latitudes. In examining the distribution of the great classes of the Vegetable Kingdom, it will be found that certain relative numerical proportions have been ascertained. It is not easy to estimate the proportion which Cryptogamous bear to Phanerogamous plants. From data already given, it may be estimated that the proportion for the whole world is as 1 to 7. This proportion varies in different regions; the Cryptogamous plants increasing in their proportion in the northern parts of the temperate zone. Ferns are to known Phanerogamous plants as 1 to 20. This proportion is least in the middle of the temperate zone, and becomes larger towards the equator, and towards the poles. Ferns, however, attain their absolute maximum at the equator, and their absolute minimum in the arctic zone. At North Cape, there are only four species of Ferns found, and yet their proportion to Phanerogamia is 1 to 7 there; and in Greenland, 1 to 10 (Meyen). Humboldt says, that in the torrid zone, Monocotyledons are to Dicotyledons as 1 to 6: in the temperate zone, as 1 to 4; and in the arctic zone, as 1 to 3. Monocotyledons increase in proportion to Dicotyledons as the latitude becomes higher. Some natural orders are very generally diffused, as Leguminosæ, Malvaceæ, Ranunculaceæ, Caryophyllaceæ, Cruciferæ, and Umbelliferæ. Cellular plants have also a wide range, and so have aquatics. Juncaceæ, Cyperaceæ, and Gramineæ, increase in proportion to all the Phanerogamous plants, as the latitude becomes higher; while Restiaceæ, Leguminosæ, Euphorbiaceæ, and Malvaceæ, decrease. Cruciferæ, Umbelliferæ, and Compositæ, are highest in their proportion in the temperate zone, diminishing towards the equator and the poles. Hinds gives the following statement as to certain families which are almost exclusively confined to one of the six great divisions of the globe:—

In Europe,—Globulariaceæ a section of Selaginaceæ, Ceratophyllaceæ.

In Asia,—Dipterocarpaceæ, Aquilariaceæ, Camelliaceæ, Moringaceæ, Stilaginaceæ.

In Africa,—Bruniaceæ, Brexiaceæ, Belvisiaceæ, Penæaceæ.

In North America,—Sarraceniaceæ.

In South America,—Rhizobolaceæ, Monimiaceæ, Simarubaceæ, Vochysiaceæ, Calyceraceæ, Escalloniaceæ, Humiriaceæ, Lacistemaceæ, Papayaceæ, Gilliesiaceæ, Gesneraceæ.

In Australasia,—Tremandraceæ, Epacridaceæ, Goodeniaceæ, Stackhousiaceæ, Brunoniaceæ.

He also gives the following list of natural orders, as prevailing in the northern hemisphere and southern hemisphere:—

In the northern hemisphere, the following natural orders abound, or are predominant:—Aceraceæ, Aurantiaceæ, Artocarpeæ a section of Urticaceæ, Amentaceæ, Berberaceæ, Boraginaceæ, Caryophyllaceæ, Cistaceæ, Cruciferæ, Coniferæ, Campanulaceæ, Caprifoliaceæ, Dipsacaceæ, Elæagnaceæ, Fumariaceæ, Grossulariaceæ, Hypericaceæ, Hippocastaneæ a section of Sapindaceæ, Hamamelidaceæ, Magnoliaceæ, Onagraceæ, Orobanchaceæ, Papaveraceæ, Rosaceæ, Ranunculaceæ, Rutaceæ, Resedaceæ, Saxifragaceæ, Umbelliferæ, Vacciniaceæ, Alismaceæ.

In the southern hemisphere, the following natural orders are predominant:—Atherospermaceæ, Cactaceæ, Crassulaceæ, Capparidaceæ, Diosmeæ a section of Rutaceæ, Dilleniaceæ, Geraniaceæ, Heliotropeæ a section of Ehretiaceæ, Myrtaceæ, Melastomaceæ, Mesembryaceæ, Myoporineæ a section of Verbenaceæ, Malpighiaceæ, Oxalidaceæ, Pittosporaceæ, Polygalaceæ, Proteaceæ, Scævoleæ a section of Goodeniaceæ, Spigeleæ a section of Loganiaceæ, Stylidiaceæ, Amaryllidaceæ, Hæmodoraceæ, Iridaceæ, Restiaceæ.

It is sometimes difficult to tell in what division of the globe a family may be said to be chiefly represented, inasmuch as the species and genera are nearly equal in different countries. When a group of plants occurs only in one of the six great divisions of the globe, it is said to be *monomic* (μόνος, one, and νομός, a region). Thus, Vochysiaceæ, being confined to South America, is a monomic family; and Cliffortia, whose shrubby species are all indigenous to South Africa, is a monomic genus. Again, a natural family, common to all the divisions, is *polynomic;* and so also genera, as Viola or Ranunculus. If restricted to two or more divisions, the groups are *dinomic*, *trinomic*, &c. Aceraceæ, found in Europe, Asia, and North America, are trinomic.

5.—PHYTO-GEOGRAPHICAL DIVISION OF THE GLOBE.

1152. The subject will be considered in two points of view:—1. In respect to the horizontal or latitudinal range of vegetation; and 2. In respect to its vertical or altitudinal range.

1153. **Horizontal Range of Vegetation.**—Various attempts have been made to divide the globe into zones or kingdoms, founded on the characters impressed upon them by the nature of the vegetation. Willdenow, Treviranus, De Candolle, Schouw, and Meyen, have each proposed arrangements. Those of Schouw and Meyen chiefly deserve attention.

1154. Schouw, in his divisions, proceeds on the principle of the predominance of certain characteristic forms or families of plants. His system is founded on the three following requisities:—1. That at least one-half of the known species of plants of that part of the earth, constituting a botanical region, should be peculiar to it. 2. That one-fourth part of the genera of the region should be peculiar to it, or at least should have so decided a maximum as to be only represented in other regions. 3. That individual families should either be peculiar to the region, or at least reach their maximum in it. The regions are divided into provinces according to minor differences in the vegetation; one-fourth of peculiar species, or some peculiar genera, being sufficient to form a province.

1155.—*Schouw's Phyto-Geographic Regions.*

1. The Region of *Saxifragaceæ* and *Musci*, or the Alpine Arctic Flora.—This region is characterized by the abundance of Mosses and Lichens, the presence of *Saxifragaceæ*, *Gentianaceæ*, *Caryophyllaceæ*, *Cyperaceæ*, *Salices;* the total absence of tropical families; a notable decrease of the forms peculiar to the temperate zone; by forests of Fir and Birch; the small number of annual plants, and the prevalence of perennial species; and finally, a greater liveliness in their simple colours. In this region there is no cultivation. The region is divided into two provinces:—1. The province of the *Carices*, or the Arctic Flora, which comprehends all the countries within the polar circle, with some parts of America, Europe and Asia, which are to the south of it, more especially Lapland, the north of Russia, Siberia, Kamtschatka, New Britain, Canada, Labrador, Greenland, and the mountains of Scotland and Scandinavia, mean temperature 36° to 41°. 2. The province of *Primulaceæ* and *Phyteumæ*, or the Alpine Flora of the south of Europe, which embraces the flora of the Pyrenees, Switzerland, the Tyrol, Savoy, the mountains of Greece, the Appenines, and probably the mountains of Spain. Mean temperature, 47° to 66°.

2. The Region of *Umbelliferæ* and *Cruciferæ*.—These tribes are here in much greater number than in any other region; *Rosaceæ*, *Ranunculaceæ*, *Fungi*, *Amentaceæ*, and *Coniferæ*, likewise very numerous; the abundance of *Carices*, and the fall of the leaves of almost all the trees during winter, form also important features of this division. It may be separated into two distinct provinces:—1. The province of the *Cichoraceæ*, which embraces all the north of Europe, not comprehended in the preceding region, namely, Britain, the north of France, the Netherlands, Germany, Denmark, Poland, Hungary, and the greater part of European Russia. 2. The province of the *Astragali*, *Halophyta*, and *Cynarocephalæ*, which includes a part of Asiatic Russia, and the countries about the Caucasian and Altai mountains. Mean temperature, 36° to 57°. The cultivated plants are—Rye, Barley of different kinds, Oats, Wheat and Spelt, Maize, Millet, the Potato, Buck-wheat, Apple and Pear, Quince, Cherry, Plum, Apricot, Peach, Mulberry, Walnut, Vine, Gooseberry and Currant, Strawberry, Cucumber and Melon, Cabbage, Mustard, Pea, Bean, Beet, Spinach, Carrot, Flax, Hemp, Trefoils and Vetches, Rye-grass, &c.

3. The Region of *Labiatæ*, and *Caryophyllaceæ*, or the Mediterranean Flora.—It is distinguished by the abundance of the plants belonging to these two orders. *Compositæ*, *Galiaceæ*, *Boraginaceæ* also occur in considerable quantity. Some tropical families are also met with, such as Palms, Laurels, *Araceæ*, *Anacardiaceæ*, grasses belonging to the

genus *Panicum* (millet), and some *Cyperaceæ*. *Solanaceæ*, *Malvaceæ*, *Leguminosæ*, *Urticaceæ*, and *Euphorbiaceæ* increase. The forests are composed chiefly of *Amentaceæ*, and *Coniferæ*, as birches, oaks, firs, &c., the copses, of *Ericaceæ* (the heath tribe,) and *Anacardiaceæ*, as the mastich. We meet in this region with a great number of evergreen trees. Vegetation never ceases entirely, but verdant meadows are more rare. Schouw divides this region into five provinces:—1. The province of the Cistuses, including Spain and Portugal. 2. The province of the *Salviæ* and *Scabiosæ*, the south of France, Italy, and Sicily. 3. The province of the Shrubby *Labiatæ*, the Levant, Greece, Asia Minor, and the southern part of the Caucasian countries. 4. The Atlantic province, the north of Africa, of which he does not yet know any distinctive character. 5. The province of *Semperviva*, the Canary Isles, and probably also the Azores, Madeira, and the north-west coast of Africa; many *Sempervivums*, and some *Euphorbias* with naked and spiny stems particularly characterize this province. *Erica arborea*, and *Pinus canariensis* are found here. Mean temperature, 54° to 72°. Cultivated plants are the same as in the second region, with the addition of Rice, Guinea Corn, Italian Millet, Fig, Almond, Orange and Lemon, Water Melon, Olive, Cotton. Rye and Buckwheat are only cultivated in the mountainous regions.

4. The Region of *Asters* and *Solidagos*.—This is marked by the great number of species belonging to these two genera, by the great variety of Oaks and Firs, the small number of *Cruciferæ* and *Umbelliferæ*, *Cichoraceæ*, and *Cynarocephalæ*, the total absence of the genus *Erica*, or heath, and the presence of more numerous species of *Vaccinium*, or whortleberry, than are to be met with in Europe. It comprehends the whole of the eastern part of North America, with the exception of what belongs to the first region. It has been divided into two provinces:—1. That of the south, which embraces the Floridas, Alabama, Mississippi, Louisiana, Georgia, and the Carolinas. 2. That of the north, which includes the other states of North America, such as Virginia, Pennsylvania, New York, &c. Mean temperature, 54° to 72°. In the northern districts, down to the parallels of 55° or 50°, there is no cultivation. South of this line, the cultivation is the same as in the second region. Maize is cultivated to a greater extent in North America than in Europe.

5. The Region of *Magnolias*, comprising the most southern parts of North America, between 36° and 30°. The tropical forms which show themselves more frequently than on a similar parallel of the old continent, are the chief feature in the vegetation. Thus we meet with *Anonaceæ*, *Sapindaceæ*, *Melastomaceæ*, *Cactaceæ*, and *Zingiberaceæ*. This region has fewer *Labiatæ* and *Caryophyllaceæ* than occur in corresponding latitudes in the Old World. It presents more trees with fine blossoms, and shining, sometimes pinnated, leaves, as Mangolia,

Tulip-tree, Horse-chestnut, Robinias or False Acacias. Mean temperature, 59° to 72°. The same plants cultivated as in the third region. Rice is much cultivated. In the southern district, the Sugar-cane is productive; and, in the eastern districts, Cotton is grown to a great extent.

6. The Region of *Camelliaceæ* and *Celastraceæ*, or the Japanese region.—This region is as yet too little known to enable us to determine accurately its characteristic features. It embraces the eastern temperate part of the old continent, namely Japan, the north of China, and Chinese Tartary, between lat. 30° and 40° north. Its vegetation appears to occupy a middle place between that of Europe, and that of North America, approaching more to the tropical than to the European. It has an affinity to the Indian Flora, as shown by the occurrence of Bananas, Palms, *Zingiberaceæ*, *Anonaceæ*, *Sapindaceæ*, and *Cycadaceæ*. We meet with *Eriobotrya japonica* or Loquat, Tea, and various species of *Citrus*. Mean temperature, 54° to 68°. The cultivated plants are —Rice, Wheat, Barley, Oats, Millet, Buckwheat, Apple and Pear, Quince, Plum, Cherry, Apricot, Peach, Loquat, Orange and Shaddock, Melon, Tea, Hemp, Paper-Mulberry, Cotton, and False Sago.

7. The Region of *Zingiberaceæ*, or the Indian Flora.—*Zingiberaceæ* here are much more numerous than in America, as well as *Leguminosæ*, *Cucurbitaceæ*, and *Tiliaceæ*, although in a less degree. In consequence of the imperfect state of our knowledge, we cannot subdivide this region into provinces. It comprehends India, east and west of the Ganges, the island of Ceylon and the south-eastern Peninsula, to the height of 4,500 to 5,500 feet above the level of the sea. Mean temperature, 65° 75′ to 81° 50′. The cultivated plants are—Rice, Coco-nut, Tamarind, Mango, Ginger, Cinnamon, Mangosteen, Peppers, Indigo, Cotton, Coffee, Bananas, Guava, Orange and Shaddock, Sugar-cane, Cloves, Turmeric.

8. The Emodic Region, or the Mountains of India.—This comprises the Alpine region south of the ridge of the Himalaya. It includes Sirmore, Gurwal, Kamaon, Nepal, and Bhotan, to a height of from 4,500 to 10,700 feet above the level of the sea. Some tropical plants grow in the lower parts of the region. Deodar, *Pinus excelsa*, *Webbiana*, andother *Coniferæ*, are met with. Mean temperature, 66° to 37°. Some European grains and fruit are cultivated, along with Mountain Rice.

9. The Region of the Asiatic Islands.—This includes the mountainous districts of the islands between the south-eastern Peninsula and Australia, to the height of 5,500 feet above the level of the sea. Mean temperature, 66° to 84°. The cultivated plants are those of the Indian region (7); also, Bread-fruit, Cassava, Nutmeg, Camphor, Papaw, and Dammar.

10. The Region of Upper Java.—This embraces those districts of the island of Java and the islands of the Indian Archipelago which

have an elevation of 5,500 feet above the level of the sea. The vegetation of this region has not been sufficiently ascertained.

11. The Polynesian Region.—This includes all the islands of the Pacific Ocean within the Tropics. Mean temperature, 72° to 82°. The cultivated plants are—Bread-fruit tree, Coco-nut, Double Coco-nut, Yams, Plantain, Cabbage, Palm, Paper-Mulberry.

12. The Region of *Aymridaceæ*, or of Balsam trees.—This comprehends the Persian or Arabian Flora, especially the south-western part of the highlands of Arabia or Yemen. In this region are many trees yielding gums and balsamic resins, as species of *Mimosa*, *Acacia*, *Balsamodendron*, *Boswellia*. Cultivated plants are—Maize, Millet, Date-palm, Coco-nut, Fig, Apricot and Peach, Plum, Apple, Quince, Vine, Coffee-tree, Tamarind, Papaw, Sugar-cane, Ginger, Cotton, and Indigo.

13. The Desert Region.—This includes Northern Africa, to the south of the mountains of Atlas, between lat. 30°and 15° N., and the northern part of Arabia. *Phœnix dactylifera*, or the Date-palm, and *Cucifera thebaica*, or Doom palm, are found here, but little is known in regard to the vegetation of the region. Mean temperature, 72° to 86°. Cultivation is confined to the valley of the Nile and the Oases. We meet with Guinea Corn, Wheat and Barley, and the South European and Indian grains.

14. The Region of Tropical Africa.—This includes that part of Africa lying between the parallel of 15°, and the tropic of Capricorn, or between the northern and southern limits of periodical rains, with the exception of Abyssinia and the unknown countries of the interior. The Flora of the western part of this region is characterized in part by *Adansonia*, or the Boabab, one of the largest known trees. We also meet with the *Elais guineensis*, a palm which furnishes oil. Other characteristic plants are *Sarcocephalus esculentus* and *Schmiedelia africana*. The vegetation of Guinea and Congo is a mixture of the Floras of Asia and America, though most resembling the former. The eastern part of the region, including Madagascar, has a peculiar Flora, distinguished chiefly by the genera *Danais*, *Ambora*, *Dombeya*, *Dufourea*, *Didymomeles*, and *Senacea*. Mean temperature, 72° to 86°. Cultivated plants: Maize, Rice, Guinea Corn and Millet, Yams, Cassava, Banana, Mango, Papaw, Pine-Apple, Cashew, Tamarind, Coffee, Sugar, Cotton, Ginger, Cardamoms, Earth-nut.

15. The Region of *Cactaceæ* and *Piperaceæ*. — This embraces Mexico, New Grenada, Guiana, and Peru. These natural orders are here predominant, both as regards the number of species and the individual plants. Murichi or Ita Palm, *Phytelephas* or Ivory Palm, and *Victoria regia*, are found in this region. Mean temperature, 68° to 86°. Cultivated plants: Maize, Guinea Corn, Cassava, Yams, Batatas, Arracacha, Arrow-root, Plantain, Mango, Custard Apples, Guava, Coco-nut, Papaw, Avocado Pear, Pine Apple, Cashew, Tamarind,

Grenadilla, Vine, Indian Fig, Jambos, Chocolate, Vanille, Coffee, Sugar, Capsicum, Cochineal-Cactus, Cotton, Earth-nut.

16. The Region of the Highlands of Mexico.—This embraces the districts which have an elevation of more than 5,500 feet above the level of the sea. Many European plants are cultivated here, as well as Maize. *Pinus religiosa* and other *Coniferæ* are found. Mean temperature, 78° to 64°.

17. The Region of *Cinchonæ*, or Medicinal Barks.—This comprises a part of the elevated regions or Cordilleras of South America, included in the torrid zone, the Andes from 5,500 to 9,000 feet. The *Cinchona* belongs exclusively to this region, and forms its principal feature. In the higher regions the Potato and Quinoa are cultivated, as well as some European grains and fruits. In the lower districts, Maize and Coffee are still cultivated. Mean temperature, 68° to 59°.

18. The Region of *Escalloniæ* and *Calceolariæ*.—It embraces the highest parts of South America, or that portion of the chain of the Andes, which has more than 9,600 feet of elevation. Besides the plants mentioned, we meet with alpine plants, as Saxifrages and Gentians, and species of *Draba*, *Arenaria*, *Carex*, *Lobelia*, and *Salvia*, besides some European genera belonging to the orders *Gramineæ* and *Cichoraceæ*, such as *Bromus*, *Festuca*, *Poa*, *Apargia*, and *Hypochæris*. Mean temperature, 59° to 34°.

19. The West Indian Region.—This includes the whole district of the Great and Little Antilles. Bananas, Plantains, Mangos, Guava, Avocado Pear, Tamarind, and many other useful plants are met with. The Flora is intermediate between that of Mexico and the northern parts of South America. Mean temperature, 59° to 78°. Cultivated plants the same as those in the fifteenth region.

20. Region of *Palmæ* and *Melastomaceæ*.—It embraces Brazil and that part of South America which lies to the east of the chain of the Andes, between the Equator and the Tropic of Capricorn. *Vellozia* and *Lichnophora* give a decided feature to the peculiar vegetation of some of the mountainous parts. Here, also, numerous large peculiar species of *Eriocaulon* occur. Species of *Croton*, *Dorstenia*, and *Heliconia* are also met with, along with arborescent *Solanums*. In place of the few mosses and lichens which cover the trunks or branches of forest trees in temperate climes, in Brazil they are bearded from the roots to the very extremities of the smallest branches with Ferns, Araceæ, Tillandsias, Cactuses, Orchids, Piperomias, and Gesneras. Mean temperature, 59° to 82°. Same plants cultivated as in the fifteenth region.

21. The Region of Arborescent *Compositæ*.—The great number of arborescent *Compositæ*, and of plants belonging to the order *Calyceraceæ*, forms the chief feature of this Flora, which approaches in a remarkable manner to that of Europe, whilst it differs entirely from

the floras of Chili, the Cape, and New Holland. This region comprehends the lower part of the basin of La Plata, and the plains which extend to the west of Buenos Ayres and Chili, between the Tropic of Capricorn and latitude 40° south. (The Flora of Chili approaches that of New Holland, the Cape of Good Hope, and New Zealand, in *Goodenia*, *Araucaria*, *Proteaceæ*, *Gunnera*, *Ancistrum*.) Mean temperature, 59° to 75°. European plants form here objects of culture. Wheat, the Vine, and the Peach, are widely extended.

22. The Antarctic Region.—This includes the countries near the Straits of Magellan, Terra del Fuego, and the Falkland Islands. There is a considerable resemblance between the vegetation here and what is seen in the north temperate zone. Polar forms display themselves in the species of Saxifrage, Gentian, Arbutus, and Primrose. There is also a resemblance between the plants of this region and those of the mountains of South America, of Chili, the Cape, and New Holland. *Fagus antarctica* and Winter's Bark occur here. Many of the common British weeds are found at the southern extremity of South America. In the Falkland Islands is found *Dactylis cæspitosa*, the Tussac grass, which furnishes most valuable fodder. Mean temperature, 41° to 46°. No cultivation.

23. The Region of *Mesembryanthema* and *Stapeliæ*.—These two genera, as well as the *Ericeæ*, Heaths, are very abundant. The latter family is found in greater quantity here than anywhere else. The region embraces the southern extremity of Africa. *Iridaceæ*, *Pelargoniums*, *Aloineæ*, *Bruniaceæ*, and *Selaginaceæ*, and various *Gnaphaliums* and *Elichrysums*, occur in this region. Mean temperature, 55° to 73°. Cultivated plants: European kinds of grain, fruit, and vegetables; also Batatas, Plantains, Tamarind, Guava, and Shaddock.

24. The region of *Epacridaceæ* and *Eucalypti*.—It comprehends the temperate parts of New Holland and Australia beyond the tropics, with the Island of Tasmania or Van Diemen's Land. Besides the plants whence it receives its name, it is characterized by the orders *Stackhousiaceæ* and *Tremandraceæ*, and by the presence of a great number of *Proteaceæ*, *Myrtaceæ*, *Stylidiaceæ*, *Restiaceæ*, *Diosmeæ*, *Casuarineæ*, and *Acacias*. *Araucaria*, or *Eutassa excelsa*, the Norfolk Island Pine, forms one of the features of the region. It is one of the most peculiar Floras. Mean temperature, 52° to 72°. In the British Colonies, the European kinds of grain and fruit are cultivated.

25. The Region of New Zealand.—This Flora, besides the plants peculiar to New Zealand, as *Phormium tenax*, New Zealand Flax, comprehends several others which belong to the extremities of America, Africa, and Australia. We find in these islands *Corypha australis*, the Australian or Southern Palm, Tree Ferns, and *Dracænas*, forests of *Dammara australis*, one of the *Coniferæ*, and many *Myrtaceæ*.

Mean temperature between latitude 34° and 36° south, from 61° to 63°. Many of the European plants are cultivated.*

1156. Meyen divides the horizontal range of vegetation into zones, taking for his basis the three ordinary divisions of the torrid, the temperate, and the frigid zone, and subdividing each hemisphere into eight smaller zones.

1157.—*Meyen's Phyto-Geographical Zones.*

A.—TORRID ZONE.

1. Equatorial Zone.—This extends 15° on both sides of the equator, and has a mean annual temperature of 78½° to 82½° F. The forms characteristic of this zone are chiefly Palmæ, Musaceæ, aborescent Gramineæ, Pandanus, Scitamineæ, Orchids, and Lianas; besides plants belonging to the orders Malvaceæ, Anonaceæ, Anacardiaceæ, Artocarpeæ a section of Urticaceæ, Lecythidaceæ, Malpighiaceæ, Sapindaceæ, Cæsalpinieæ a section of Leguminosæ, Cedrelaceæ, and many others.

2. The Tropical Zone.—This reaches from the 15th degree on each side of the equator to the tropics, in 23° latitude. Mean temperature 73½° to 78¾°. Summer temperature, 80½° to 86°; winter temperature in the eastern coast countries, 59°. Besides many equatorial forms, as Palms, Musaceæ, Scitamineæ, Meliaceæ, Anonaceæ, Sapindaceæ, Orchidaceæ, Araceæ, and Lianas, there are in this zone Tree-ferns, and plants belonging to Convolvulaceæ, Melastomaceæ, and Piperaceæ.

B.—TEMPERATE ZONE

3. Subtropical Zone.—This extends from the tropics, 23° to 34° of latitude. Mean temperature, 62½° to 71½°; summer temperature, 73½° to 82½°. There is a number of tropical fruits in this region. The winters are mild, and vegetation is green throughout the year. In the northern division of the zone, Palms and Bananas grow on the plains. The Date-palm, Doom-palm, Chamærops Palmetto, many succulent Mesembryaceæ and Crassulaceæ, arborescent Euphorbias, Camellia, Thea, Aucuba, and Magnolias, are met with. In the southern division are Proteaceæ, Myrtaceæ, Epacridaceæ, Ericaceæ, many Compositæ, Diosmeæ, Zamias, and Cactaceæ.

4. The warmer Temperate Zone.—It embraces the space between 34° and 45° of latitude, including the southern part of Europe, Asia Minor, north of China, and Japan. Mean temperature, 53½° to 62½°. Summer temperature in North America, 77°; in Europe, 75¼° to 68°; in Eastern Asia, 82¼°; Winter temperature in the New World, 44½° to 32½°; in Europe, 50° to 34¾°; in Eastern Asia, 26½°. Many subtropical forms occur. Evergreen dicotyledonous trees and

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* See a Coloured Delineation of these Regions in Johnston's Maps.

shrubs, Cistuses, many species of Ericaceæ, Lauraceæ, and Myrtaceæ, and the Vine, are met with. In some parts of the zone, Solidagos and Asters, Magnolias, and Smilaceæ, abound; while in others there are representatives of the Mimosa form, Myrtaceæ, and Proteaceæ.

5. The colder Temperate Zone.—This includes a belt from 45° to 58° latitude. Mean temperature, 43° to 53½°. Minimum summer temperature on the West Coast, 56¼°; in the interior of the Continent, 68°; Minimum winter temperature in the interior of Europe, 14°. England, the north of France, and Germany, supply the characteristics of the vegetation of this zone. It embraces the region of Umbelliferæ, and Cruciferæ of Schouw. Meyen selects plants having a more marked physiognomic effect, such as ordinary Dicotyledonous trees, along with Abietineæ, and heaths covered with Calluna vulgaris.

6. The Subarctic Zone.—This reaches from 58° latitude to the arctic circle, 66°. Mean temperature, 39¼° to 43°. Summer temperature in the New World, 66¼°; in the Old World, 60¾° to 68°; Winter temperature of the former, 14°; of the latter (Western Europe), 24¾°; of the interior of Russia, 14° to 10½°. It is characterized by Firs and Willows in the northern hemisphere.

C.—FRIGID ZONE.

7. The Arctic Zone.—This extends from the Arctic circle, 66° to 72°. Mean temperature, 28½° to 32°, and towards the eastern and continental portions, far below the freezing point. The Birch, and some Coniferæ, may be said to characterize this zone.

8. The Polar Zone.—This includes all lands from 72° to 82° latitude. The mean temperature of one point in this zone, viz., Melville Island, is 1½°. In the Old World, the mean temperature is 16½°. Summer temperature of the New World, 37½°, and of the Old, 38¼°; Winter temperature, —28° in the New, and —2¼° in the Old World. No trees nor bushes grow in this zone. Some Saxifrages, and numerous Cryptogamic plants, as Lichens, prevail in it.

1158. **Vertical Range of Vegetation.**—Under this head we consider the changes produced in the physiognomy of vegetation on ascending mountains. It has reference to the distribution of plants in an altitudinal or hypsometrical point of view. This geographical range is best seen in the high mountains of tropical countries, where all gradations are met with, from the heat of the torrid zone to the cold of the frigid zone. Humboldt, in describing South American scenery, remarks:— "In the burning plains, scarce raised above the level of the Southern Ocean, we find Bananas, Cycadaceæ, and Palms in the greatest luxuriance; after them, shaded by the lofty sides of the valleys in the Andes, Tree Ferns; next in succession, bedewed by cool misty clouds, Cinchonas appear. When lofty trees cease, we come to Aralias, Thibaudias, and myrtle-leaved Andromedas; these are succeeded by Bejarias abounding in resin, and forming a purple belt around the mountains. In the stormy regions of the Paramos, the more lofty plants and showy flowering herbs disappear, and are succeeded by large meadows covered with grasses, on which the Llama feeds. We now reach the bare trachytic rocks, on which the lowest tribes of plants flourish. Parmelias, Lecidias, and Leprarias, with their many-coloured sporules, form the flora of this inhospitable zone. Patches of recently fallen snow now begin to cover the last efforts of vegetable life, and then the line of eternal snow begins."

1159. On the mountains of temperate regions the variety is rather less, but the change is not less striking. "We begin to ascend the Alps, for instance, in the midst of warm vineyards, and pass through a succession of oaks, sweet chestnuts, and beeches, till we gain the elevation of the more hardy pines and stunted birches, and tread on pastures fringed by borders of perpetual snow. At the elevation of 1,950 feet, the vine disappears; and at 1,000 feet higher, the sweet chestnuts cease to grow; 1,000 feet farther, and the oak is unable to maintain itself; the birch ceases to grow at an elevation of 4,680, and the spruce fir at the height of 5,900 feet, beyond which no tree appears. The Rhododendron ferrugineum (the Rose of the Alps) then covers immense tracts to the height of 7,480 feet, and Salix herbacea creeps 200 or 300 feet higher, accompanied by a few Saxifrages, Gentians, and Grasses, while Lichens and Mosses struggle up to the imperishable barrier of perpetual snow." In central and southern Europe, the proportion of Monocotyledons to Dicotyledons, which is as 1 to 4 in the plains, decreases with the elevation on dry mountain slopes, till at the height of 8,526 feet, it is as 1 to 7. Moist mountain slopes favour Monocotyledons, the proportion on them being as 1 to 3.

1160. The following table shows the height at which corn and trees grow in different quarters of the globe:—

	Torrid Zone.		Temperate Zone.			Frigid Zone.
	Andes 0° Lat.	Mountains of Mexico, 20° Lat.	Caucasus, 42° 30′	Pyrenees, 43°	Alps, 46°	Lapland [illegible]
Inferior limit of perpetual snow........	15,200 feet.....	13,478......	9,900.....	8,400	8,220....	3,300
Upper limit of trees,	10,800 —.....	12,000......	6,700.....	7,020.....	6,000.....	1,500
Distance between trees and snow....	4,400 —.....	1,478......	3,200.....	1,380.....	2,220.....	1,800
Distance between snow and corn....	5,200 —.....		......3,780.....		.....4,200.....	2,700

In the Himalaya, the upper limit of trees on the south side is marked by Quercus semecarpifolia, at 11,500 feet, and on the north side by Betula alba, at 14,000 feet. The Birch also forms the limit on the

Caucasian mountains. On the Pyrenees and Alps, the limit of trees is marked by Coniferæ; on the Pyrenees, by Pinus uncinata; on the south side of the Alps, by Larix europæa, the Larch; and on the north side, by Abies excelsa. In Lapland, the Birch forms the upper limit of trees. The upper limit of shrubs is determined by the Rhododendrons in the Old World, on the Pyrenees at 8,312 feet, and on the Alps, at 7,480; and by Bejarias on the Andes, at the height of 13,420 feet. On the south side of the Himalaya, Juniperus, Salix, and Ribes, form the upper limit of shrubs, at 11,500 feet; on the north, Genista versicolor ascends to 17,000 feet.

1161. The following have been given by some authors as the **zones of Alpine vegetation**:—

1. Region of Lowland cultivation. Its extent of elevation is at the spot where the prevailing cultivated plants of the latitude cease to be productive. In Mount Ætna, it rises to 3,300 feet; on Teneriffe, to nearly 3,000 (zone of vines). It embraces two zones of the Cactus and Euphorbia in the Canaries. In Madeira, it embraces two regions of Spix and Martius; the region of tropical plants reaching to 700 feet, and the region of the vine, fruit, and corn, to 2,300. In Norway, Sweden, and Finmark, it is narrow. In the Carpathians, it rises to 1,500 feet. Within the tropics, it is a broad and important region. On the Andes, at Quito, it only ceases at 5,000 or 6,000 feet.
2. Region of Woods. A magnificent region in all Alpine districts, and well characterized on the Andes and Himalaya. Humboldt notices it in Teneriffe. In Ætna, it extends to 6,200 feet. In the Canaries, to 4,080. In Madeira (region of Chestnut), to 2,950. In Lapland, it extends to 800 feet. In Finmark, 70° north latitude, to 730.
3. Region of Shrubs. Region of Retama (Spartium nubigenum) in Teneriffe. On the Pyrenees and Mount Blanc, it is extensively covered to about 9,000 feet with Rhododendrons. In the Andes, about Quito, it reaches 13,000, and is conspicuous for its shrubby compositæ. In Madeira, it embraces Kuhl's regions of Spartium and Heath. On the mountains of Lapland, it attains 1,000 feet, and is characterized by Betula nana, Vaccinium, and Salix. In Finmark, its limits are 1,100.
4. Region of Grasses. These predominate in certain Alpine situations, and in certain parallels of latitude. In South Shetland, none of the islands exhibit any Phanerogamous vegetation, with the exception of straggling grass. In Melville Island, 75° north latitude, the proportion of grasses to Phanerogamous plants is 1 to 5; in Great Britain, 1 to 12½. In the Andes, the region is traced to Paramos, and occupies a space of 13,000 to 14,500 feet; here are large cattle farms. In the Himalaya, a fine green sward is often seen at 14,600 feet. In Teneriffe, it is distinguished by Humboldt. On the Swiss Alps, Poa annua exists at an elevation of 7,400 feet.
5. Region of Cryptogamous plants. This is well marked in many places. Colonel Hall, in Chimboraço, under the Equator, at nearly 16,000 feet, found Draba aretoides, and Culcitium rufescens; still higher, a moss, which may be considered as having attained the highest limit on the globe at which vegetable life exists. Lichens are the latest plants met with in ascending Teneriffe, the Himalaya mountains, and the Alps.

1162. In the mountains of the torrid zone, the following regions are described by Meyen, corresponding to the zones given in his horizontal range of vegetation:—

1. The region of Palms and Bananas, extending from the level of the sea to 1,900 feet of altitude. It corresponds to the Equatorial zone.
2. Region of Tree Ferns, and species of Ficus, extending from 1,900 feet to 3,800. (Tropical zone.)
3. Region of Myrtaceæ and Lauraceæ, extending from 3,800 to 5,700 feet. (Subtropical zone.)
4. Region of Evergreen Dicotyledonous trees, extending from 5,700 to 7,600 feet. (Warm Temperate zone.)
5. Region of Deciduous Dicotyledonous trees, extending from 7,900 to 9,500 feet. (Cold Temperate zone.)
6. Region of Abietineæ, the Pine and Fir, extending from 9,500 to 11,400 feet. (Subarctic zone.)
7. Region of Rhododendrons, extending from 11,400 to 13,300 feet. (Arctic zone.)
8. Region of Alpine plants and Lichens, extending from the upper limit of shrubs to the snow line at 15,200 feet. (Polar zone.)*

1163. **Zones of Marine Vegetation.**—The ocean, as well as the land, possesses its vegetable forms, which vary according to their position, surrounding medium, relative degrees of pressure, and exposure to light. Harvey has observed that some sea weeds seem to be unaffected by circumstances of this nature, and are found equally abundant under opposed latitudes and in extremes of temperature. The lower we descend in the scale of marine vegetation the better is this illustrated. Many of the Diatomaceæ seem to be generally distributed.

1164. Lamouroux has estimated the marine Algæ as ranging from 5,000 to 6,000, which he has shown are distributed in various regions. Their distribution is much influenced by the degree of exposure to light, as well as by the motion of the waves. Great depths of the ocean are observed to exercise an influence on marine vegetation, similar to that which high mountains have on land plants. Some species, as the Laminariæ, are confined to the colder regions of the sea, while others, as the Sargassa, are only found where the mean temperature is considerable. The colour of Algæ may be regarded as being in a measure indicative of their depth of growth, the Algæ of green colour being generally found either in fresh water or in the shallower parts of the sea; the olive-coloured Algæ abound most between tide marks; those of a red colour occur chiefly in the deep and dark parts of the sea.

Marine vegetation is found to vary both in its horizontal and vertical range. This difference is less decided than that which is observable amongst land plants, owing probably to the greater uniformity of the ocean's temperature. The ocean has been divided into the following provinces of marine vegetation:—1. The Northern Ocean, from the Pole to the 60th parallel of north latitude. 2. The North Atlantic, between the 60th and 40th parallels, the province of the species of Fucus proper. 3. The Mediterranean, which is a sub-region of the warmer temperate zone of the Atlantic, lying between the 40th and 23d northern parallels. 4. The tropical Atlantic, in which Sargassum abounds. 5. The Antarctic American regions from Chili to Cape Horn, and the whole circum-polar ocean south of 50° of latitude. 6. The Australian and New Zealand province. 7. The Indian Ocean and Red Sea. 8. The Japan and China seas, besides certain provinces in the Pacific.

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* On the subject of Botanical Geography, the student may consult Meyen's work printed by the Ray Society; Hooker's Treatise in Murray's Encyclopædia of Geography; Malte Brun's Physical Geography; Humboldt's Narrative, &c.; Berghaus's Maps, edited by A. K. Johnston; Rudolf's Pflanzen-Decke der Erde; Hooker's New Zealand Flora (Introductory Essay); and De Candolle, Geographie Botanique, the standard work on this subject.

1165. Forbes remarks of the vertical range, that one great marine zone lies between high and low water mark, varying in species according to the nature of the coast. This zone is generally uniform throughout the northern hemisphere. A second zone begins at low water mark, and extends to a depth of 7 to 15 fathoms. The first of these, or the littoral zone, has been divided into sub-regions, in which certain marine species are found to prevail. 1. The sub-region of Fucus canaliculatus. 2. The sub-region of Lichina. 3. The sub-region of Fucus articulatus, F. nodosus, and Corallina officinalis. 4. The sub-region of Fucus serratus. The second or Laminarian zone includes the great Tangle sea-weeds and deep-water Fuci. The lowest forms of vegetable life do not, in British seas, extend deeper than 50 fathoms. In the Mediterranean and the Ægean Sea, the Coralline zone ranges from 50 to 100 fathoms. The lowest forms of marine vegetation are alone met with in the deepest waters.

1166. Marine vegetation is equally various in its horizontal range. In the North Sea and the British Channel, Chorda Filum is found to constitute beds of 15 to 20 miles in length, and about 600 feet in breadth. Sargassum bacciferum constitutes the Gulf-weed of the Atlantic. It occupies the eddy caused by the revolution of the Atlantic current, and extends over a space of 260,000 square miles. It appears to derive its sustenance wholly from the ocean, inasmuch as it has never been found attached. The Macrocystis pyrifera, and the Laminiaria radiata are remarkable for the size and extent of their range. Immense green masses of the Macrocystis are met with in every latitude. The tribe Fucoideæ are met with in abundance towards the poles, in which regions they are observed to attain their greatest bulk, diminishing and ceasing as they approach the Equator. Cystoseireæ follow a course in the higher latitudes of the southern hemisphere similar to the Fucoideæ. Laminarias inhabit the antarctic ocean, and stretch northwards to the Cape of Good Hope. The red, green, and purple Lavers of the British seas are found at the Falkland Islands.

Species which are found abundantly in one sea may be scarcely present in another. This is seen in the difference between the marine vegetation of the Red Sea as compared with that of the Mediterranean, and that of the Mediterranean as contrasted with the Atlantic. The genera Sargassum and Caulerpa of the Red Sea are represented in the Mediterranean, by very few, and those distinct species. The genus Fucus, which is common in the Atlantic, is almost entirely wanting in the Mediterranean. Many Florideæ which abound in the open seas do not adorn the rocks in the Mediterranean.

1167. **Distribution of Plants in Britain.**—The climate of Britain is influenced by its geographical position, and the form and elevation of its surface. The eastern coasts partake more of the continental climate, while the western experience the insular or more equable climate. The mean temperature varies from 46° to 52° F. In ascending the mountains there is a fall of 1° of the thermometer on an average for every 240 or 250 feet of ascent. The Phanerogamous species and varieties amount to nearly 1,600; the Cryptogamous to about 2,800. Mr. H. C. Watson, who is our chief authority on the geography of British plants, in his earlier works gives the following distribution in ascending regions:—

1. The region of the Plains. This includes all the low and open country from the south coast of England to the borders of the Highlands, in lat. 56° 56½°, terminating at the sea level on the shores of the Clyde and Tay. It contains the common weeds and wild flowers of the country, and among trees, the Oak, Ash, &c.
2. Upland Region. This is marked by the occurrence of Vaccinium Vitis-Idæa, Arctostaphylos Uva-Ursi, Polygonum viviparum, Trientalis europæa, Linnæa borealis, &c.
3. Median Region. A narrow belt just above the upper limit of cultivation, and the growth of Amentaceæ such as the Oak and Hazel.
4. Subalpine Region. This commences at from 1,500 to 2,400 feet above the level of the sea. Juncus trifidus, Saxifraga nivalis, and Gnaphalium supinum occur here.
5 Alpine Region. This region is only truly seen in Scotland. Saxifraga cernua and rivularis, Draba rupestris, Luzula arcuata, Stellaria cerastoides, and Alsine rubella, may be said to characterize it.

Of late years, Mr. Watson has proposed the following geographical division of British plants:—

1. Agrarian. Plants found only within the limits of cultivation, or within the limits of Pteris aquilina, in waste land, the elevation or climate of which would not forbid successful cultivation.
2. Arctic-Agrarian. Plants found within the region of cultivation, and also above these limits.
3. Arctic. Plants found only above the limits of cultivation.

1168. In considering the distribution of British plants in connection with geographical or local position, Watson suggests the following types:—

1. Atlantic type: embracing species found in the south-west of England and Wales, as Erica ciliaris, Sibthorpia europæa, and Euphorbia Peplis.
2. Germanic type: including species chiefly seen in the south-west of England, the chalk plants, as Phyteuma, Ophrys, Hippocrepis, and Onobrychis.
3. The English type: consisting of species chiefly or exclusively found in England, and decreasing in frequency northwards, as Acer campestre, Tamus communis, Iris fœtidissima, Orchis Morio.
4. British type: comprehending species widely spread over Britain, as Bellis, Calluna, Corylus.
5. Scottish type: embracing species prevalent chiefly in Scotland, or the north of England, as Trollius, Linnæa, Andromeda, Primula farinosa.
6. The Highland type: containing species either limited to the Scottish Highlands, or extending to the mountains of the north of England and Wales, as Salix herbacea, Azalea, Arctostaphylos, Lobelia, Subularia.
7. Hebridean type: composed of a few species peculiar to the extreme north and west of Scotland, or at least chiefly seen there, as Eriocaulon septangulare, Ajuga pyramidalis, Primula scotica.

1169. Professor E. Forbes has adopted Mr. Watson's view. He thinks that the vegetation of the British islands may be said to be composed of five floras:—1. A west Pyrenean, confined to the west of Ireland, and mostly to the mountains of that district. 2. A flora related to that of the north-west of France, extending from the Channel Isles, across Devon and Cornwall, to the south-east and part of the south-west of Ireland (Watson's Atlantic type). 3. A flora common to the north of France and south-east of England, and especially developed in the chalk districts (Watson's Germanic type). 4. An Alpine flora, developed in the mountains of Wales, north of England, and Scotland (Watson's Highland type). 5. A Germanic flora, extending over the greater part of Great Britain and Ireland, mingling with the other floras, and diminishing, though slightly, as we proceed westwards, indicating its easterly origin and relation to the characteristic flora of northern Germany (Watson's British, English, and Scottish types). In attempting to account for the peculiarities of these floras, most of which had been previously noticed by Mr. Watson, Professor Forbes enters into some geological speculations, which, although entirely conjectural, are well worthy of consideration. He numbers in ascending order these floras, according to their magnitude as to species, and also, in his opinion, according to their relative age and period of introduction into the area of the British islands. His conclusions on this point are the following:—

"1. The oldest of the floras now composing the vegetation of the British isles, is that of the mountains of the west of Ireland. Though an Alpine flora, it is southernmost in character, and is quite distinct as a system from the floras of the Scottish and Welsh Alps. Its very southern character, its limitation, and its extreme isolation, are evidences of its antiquity, pointing to a period when a great mountain barrier extended across the Atlantic from Ireland to Spain.

"2. The distribution of the second flora, next in point of probable date, depended on the extension of a barrier, the traces of which still remain, from the west of France to the south-east of Britain, and thence to Ireland.

"3. The distribution of the third flora depended on the connection of the coast of France and England towards the eastern part of the channel. Of the former existence of this union no geologist doubts.

"4. The distribution of the fourth, or Alpine flora of Scotland and Wales, was effected during the glacial period, when the mountain summits of Britain were low islands, or members of chains of islands, extending to the area of Norway through a glacial sea, and clothed with an arctic vegetation, which in the gradual upheaval of those islands and consequent change of climate, became limited to the summits of the new-formed and still existing mountains.

"5. The distribution of the fifth, or Germanic flora, depended on the upheaval of the bed of the glacial sea, and the consequent connection of Ireland with England, and of England with Germany, by great plains, the fragments of which still exist, and upon which lived the great elk and other quadrupeds now extinct.

"The breaking up or submergence of the first barrier led to the destruction of the second; that of the second to that of the third; but the well-marked epoch of migration of the Germanic flora indicates the subsequent formation of the straits of Dover and of the Irish Sea, as now existing.

"To determine the probable geological epoch of the first or west-Irish flora—a fragment, perhaps with that of north-western Spain, of a vegetation of the true Atlantic—Forbes seeks among fossil plants for a starting-point. This he gets in the flora of the London clay, or Eocene, which is tropical in character, and far anterior to the oldest of the existing floras. The geographical relations of the Miocene sea, indicated by the fossils of the crag, give an after-date certainly to the second and third of the above floras, if not to the first. The epoch of the red or middle crag was probably coeval with the second flora; that of the mammaliferous crag with the third. The date of the fourth is too evident to be questioned; and he regards the glacial region in which it flourished as a local climate, of which no true traces—as far as animal life is concerned—exist southwards of his second and third barriers. This was the newer Pliocene epoch. The period of the fifth flora was that of the post-tertiary, when the present aspect of things was organized.

"Adopting such a view of the relations of these floras in time, he thinks that the greatest difficulties in the way of changes of the earth's surface and destruction of barriers—deep sea being found where land (probably high land) was—are removed when we find that those greater changes must have happened during the epoch immediately subsequent to the Miocene period; for we have undoubted evidence that elsewhere, during that epoch, the Miocene sea-bed was raised 6,000 feet in the chain of Taurus, and the barriers forming the westward boundary of the Asiatic Eocene lakes so completely annihilated, that a sea several hundred fathoms deep now takes their probable place. The changes required for the events which he would connect with the peculiar distribution of the British flora are not greater than these. Professor Forbes thinks that the peculiar distribution of endemic animals—especially that of the terrestrial mollusca—bears him out in these views."

1170. The observations of Watson and Forbes lead to the conclusion that, with the exception of Eriocaulon septangulare, the British islands do not contain a single plant which is not found on the continent of Europe. These islands, therefore, cannot be considered as a centre of vegetation, but as having been colonized by successive vegetable migrations. Their opinion as to the origin of British plants, as condensed by Martins, is, that these islands have been peopled by many colonies successively leaving the continent of Europe, from the epoch of the middle tertiary formation up to our own. When a vast continent extended from the Mediterranean regions to the British islands, the plants of the Asturias, and those of Armorica, peopled the south of England and Ireland. To this period succeeded the glacial epoch, during which the lands were immerged to a depth of about 1,300 or 1,400 feet. This is the period of the migration of the arctic plants, which still inhabit the tops of the Scottish mountains. When these lands emerged anew, England was united to France, the temperature being such as it is at present. At this time, the great German floral invasion took place, absorbing, so to speak, all the rest, and leaving very slight remains of them. Thus, while the Asturian plants, those of the south, are reduced to a small number of species confined to the south-west of Ireland, the hardy vegetables of the north completed their conquest. The colonization being completed, England became separated from the continent.

1171. Martins agrees with Watson and Forbes in their general views of the British flora, adopting the following types :—

1. Asturian type—the remains of a Peninsular flora.
2. Armorican type—vegetation like that of Brittany and Normandy.
3. Boreal type—flora like that of the Swiss Alps, Lapland, Iceland, and Greenland.
4. Germanic type—the basis of the vegetation of England.

He thinks, that while Europe has had the principal part in the colonization of the British islands, a great vegetable migration has also taken place from America; and that the arctic plants originating in Greenland, have propagated themselves across Iceland, Feroe, and Shetland, as far as the mountains of Scotland. These mountains have therefore derived their flora partly from Norway and partly from Greenland, by a sort of double migration. His opinion is founded on the fact, that the relative proportion of plants, exclusively European, which enter into the flora of Shetland, is $\frac{1}{4}$; into that of Feroe, $\frac{1}{7}$; and into that of Iceland, $\frac{1}{10}$; all the rest being common to Europe and America. In proportion, therefore, as we remove from Europe, the number of vegetables peculiar to that continent diminishes; but at the same time the proportion of the Greenland plants increases in nearly the same ratio. Martins, however, does not agree with Forbes in his bold and novel hypothesis, but attributes the colonization to the transport of seeds from America and Europe, by means of the gulf stream. This stream, he thinks, has thrown Eriocaulon septangulare on the shores of the Hebrides, and, running along the coast of Scotland, carries seeds to the sandy shores of Shetland, Feroe, and Iceland. He considers it the principal agent in the diffusion of European plants in these islands. Winds, aerial currents, and birds, he thinks, have also contributed to the dissemination of species.*

1172. **Acclimatizing of Plants.**—It is commonly supposed that by length of time plants may be rendered fit to endure a climate which they could not stand in the first instance. It has been said, that by slow degrees tender plants may become acclimatized to cold climates. Such a view, however, is totally inconsistent with the facts of the case. Each species of plant naturally bears a certain range of temperature, and it is impossible to extend that range. Many plants originally placed in greenhouses, and subsequently planted out, are held up as cases of acclimatization. Aucuba japonica, coming from a warm climate, was at first treated in this country as a stove-plant, and was afterwards planted out, and was found to endure the climate, but no change was made in the constitution of the plant. It was capable from the first of enduring the cold of this climate. Aponogeton distachyum, an aquatic from the Cape, was cultivated long in the stoves of the Edinburgh Botanical Garden. A specimen was accidentally thrown into the open pond, where it has continued to live and flower for many years. The constitution of the plant is unaltered. It was able to bear a certain range of temperature, but cultivators were not aware of this in the first instance. Plants sent from warm countries, and supposed to be delicate, are often quite hardy, inasmuch as their native locality has been high on the mountains. Such is the case with Araucaria imbricata from Chili, and with some Nipal and Japan plants. Again, take the Potato, the Dahlia, Heliotrope, and Marvel of Peru, which have been long cultivated in Britain, and it will be seen that they are not in the slightest degree more hardy than when first introduced; they are injured by the frost just as easily as at first.

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* For further details on the subject of the Geography of British plants consult Watson's Distribution of British Plants, and Cybele Britannica; Forbes's paper in the Reports of the Geological Survey of Great Britain; Martins' papers in the Edinburgh Philosophical Journal for 1848.

1173. Something, however, may be done by the art of the gardener, to render half-hardy species of plants less tender. In this climate, the great risk in such cases, is frequently not so much the degree of cold, as the accession of it at a time when the plants cannot resist it, in consequence of being full of sap. Attention, therefore, should be paid to bringing the plants into as dry a state as possible, at the beginning of winter. Lindley remarks that the only means of effecting this consists in thoroughly drained soil, and an elevated situation—the first preventing a plant from filling itself with moisture during winter, or overgrowing itself in summer, so as to enable it to ripen its wood; and the latter securing it from the action of those early frosts in autumn, or those late frosts in spring, which are so pernicious even to our own wild trees. In an elevated situation, a plant also escapes the risk of being stimulated into growth by a few days' warmth, succeeded by nipping colds, which so often occurs in our variable climate.

PART IV.

FOSSIL BOTANY.

1174. The history of vegetation could not be considered complete, unless we endeavoured to give some account, however brief, of the plants which existed on the earth in its primeval state, during the extended geological epochs which elapsed before the establishment of the present order of things. This subject is alike interesting to the botanist and the geologist. It has sometimes been called Geo-Botany, and is an important section of Oryctology (ὀρυκτὸς, fossil). "Geology," says Philips, "would never, perhaps, have escaped from the domain of empiricism and conjecture, but for the innumerable testimonies of elapsed periods and perished creations, which the stratified rocks of the globe present, in the remains of ancient plants and animals. So many important questions concerning their nature, circumstances of existence, and mode of inhumation in the rocks, have been suggested by these interesting reliquiæ; and the natural sciences have received so powerful an impulse, and been directed with such great success to the solution of problems concerning the past history of the earth, that we scarcely feel disposed to dissent from the opinion, that without fossil Zoology and Botany, or what is denominated Palæontology (παλαιός, ancient), there would have been no true Geology." The stratified crust of the globe is full of these monuments of vanished forms of life. They are of various kinds, are in different states of preservation, and occur very unequally in rocks of different kinds and ages. The remains of ancient vegetation are very abundant in the coal measures, the important combustible material derived from them, and which is vegetable matter in an altered form.

1175. **Characters and Arrangement of Fossil Plants.**—From the state in which fossil plants are found, it is by no means an easy matter to determine their nature accurately. Brongniart states that the preservation of vegetables, in a fossil state, may be effected—1st, By the impression or cast of the plant being discoverable, though accompanied by a complete destruction of the vegetable tissue, or the preservation of but a few of its constituent parts; 2d. By petrifaction or carbonization, which preserves more or less completely the structure of the tissues of vegetable organs, by changing or only modifying their nature. The impression or cast, without the preservation of any portion of the organs of the vegetable more or less altered, is rather rare; yet it is the habitual state of fossil vegetables in the variegated sandstone and tertiary limestones.* It is rarely that any of the essential organs are found in such a state of preservation as to furnish distinct characters. It is chiefly from the fragments of stems, and the impressions of leaves, and some fruits, that the fossil botanist can draw conclusions. Besides this, fossil vegetables, thus reduced to some of their insulated organs, scarcely ever present them in such a state of preservation as enables them to be studied in all their constituent parts. Sometimes the internal structure of the stem can be traced, and by examination under the microscope, the nature of its woody tissue may be determined. In this way some fossilized woods have been referred to the Coniferous tribe, in consequence of the presence of punctated woody tissue (fig. 47). Fossil woods have been shown by chemical tests to contain portions of vegetable tissue, cemented into a mass by silica. In some cases the vessels and cells are separately silicified without being united into a compact mass. In these instances the wood breaks down easily. At times the internal structure is obliterated, and it is only from the external configuration, the nature of the outer covering, and the scars of the leaves, that any conclusions can be drawn. The leaves often furnish important and valuable characters, and, in the case of fossil ferns, their form, divisions, and venation, supply distinguishing marks. The leaves, however, are generally isolated, and are rarely found in connection with the stems. Thus, the separation of the different parts of the plant, and, in most cases, their imperfect state of preservation, are great obstacles in preventing the determination of fossil plants by a comparison with those which now exist on the earth. Before, then, endeavouring to compare a fossil vegetable with living vegetables, it is necessary to put together, with as much exactness as possible, according to the parts preserved, and the general data of vegetable anatomy and organography, the portions of the plant under examination; to contrast these portions with the other organs of the same plant, searching for their points of attachment, their forms and vascular connections, being guided generally by traces of strucsure rather than by exterior form; and by endeavouring to reconstruct a vegetable by bringing together all fragments from the same fossil beds, which may belong to the same plant. The connection of the different parts of the same plant is of the greatest importance in vegetable palæontology, as from their fragmentary nature many difficulties arise. These difficulties are increased as we go back to the earliest geological epochs, for the farther they are removed from the present state of things, the greater are the differences between the fossil and living plants. Dr. Hooker remarks, that the knowledge of recent botany required to throw light upon the study of fossil plants, and the origin of coal, must be both varied and extended. "Some acquaintance with systematic botany is the first requisite; through this alone can any approximation to the living affinities of the fossil be obtained. It should embrace not only a knowledge of the principal groups, or natural orders under which all plants are arranged, but a familiarity with vegetable anatomy; for when the stem or trunk alone is preserved, which is often the case, a minute examination of its tissues is the sole method of determining its position in the natural series. There must also be some general ideas of the vegetation both of the tropics and cooler latitudes, of mountain-chains, table-lands, valleys and estuaries; more especially of countries characterized by equable, and by excessive or extreme climates, as compared with continents, and of humid and desert districts; in short, of all the complex associations with, or dependence of botanical characters upon, surface, soil, and climate, which the globe presents."

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* Brongniart, Tableaux des Vegetaux Fossiles.

1176. Many of the fossil plants of the tertiary or recent strata may be referred to genera at present existing, and merely present specific differences; such as pines, elms, beeches, maples, &c. Those of the secondary strata may, in general, be referred to known families, but in most instances require the formation of new genera; while those of the older strata, in numerous instances, cannot be classed in existing families, and must constitute new groups. Such are the Calamites, Lepidodendrons, and Sigillarias of the coal formation. From all the investigations of fossil botanists, however, it appears that the same great types existed in a former state as at the present day, viz., Cellular Cryptogamics, Vascular Cryptogamics or Acrogens, Monocotyledons and Dicotyledons, both Angiospermous and Gymnospermous.

1177. Schlotheim, Sternberg, Brongniart, and others, have proposed arrangements of fossil plants. That of Brongniart is founded on the resemblances which the fossils bear to living plants. He divides them as follows:—

1st. Amphigenous Cryptogamous Plants, or Cellular Cryptogams, which he subdivides into two classes, the Fungi and Algæ.

2d. Acrogenous Cryptogamous Plants, comprehending two classes, the Musci and Filicales; the latter being divided into five families—the Ferns, Marsileaceæ, Characeæ, Lycopodiaceæ, and Equisetaceæ.

3d. Dicotyledonous Phanerogamous Plants, of which he enumerates the several families, indicating the characters which approximate them to the same families of living vegetables.

4th. Monocotyledonous plants.[*]

When the analogy between a fossil and a living plant is such that the difference is not greater than occurs among the individuals included in a species of the living genus, then the fossil and living plant may be considered identical, and the epithet of fossil is applied to the name of the plant. If, on the other hand, the fossil presents distinct specific characters, but does not differ more from living species than these species differ among themselves, then it is looked upon as a new species of the genus. If the differences are well marked, but at the same time the organ which represents them is not of sufficient importance to induce the belief that the plant differs from others of the genus in all its essential organs, then the termination *ites* is added to the name of the genus. Thus, Lycopodites is a genus of fossil plants allied to Lycopodium, apparently not differing, so far as known, in essential and important parts; so also Zamites allied to Zamia, Thuyites to Thuya. If a fossil plant, although presenting several essential characters of a family, yet differs in the fossilized organ from all the known genera of the family, as much or more than these genera do among themselves, then it is to be considered as a new genus different from those actually existing. This will be seen in many of the coal fossils.

1178. Before proceeding to notice some of the more important fossil plants, it will be necessary to give a sketch of the geological constitution of the globe. The rocks of which the earth is composed are either stratified or unstratified; and the former are either fossiliferous or non-fossiliferous (azoic). The unstratified rocks, included under the names of Granitic and Trappean, are considered igneous, plutonic, or eruptive rocks, and do not generally exhibit any fossiliferous deposits. Vegetable structures in an altered condition have, however, been found in the substance of Trap rocks. Distinct evidences of Dicotyledonous structure charred have been discovered in various situations, more particularly near the Giant's Causeway, in Antrim, under the Trap rocks in the Island of Mull, and in those rocks of the same nature which are near Edinburgh. Fossil plants have not been found in certain metamorphic rocks such as Gneiss and Mica-slate, which present a stratified appearance, and appear to have been deposited in peculiar circumstances, probably at a high temperature. The igneous and metamorphic rocks are sometimes included under the comprehensive name of Hypogene. The non-discovery of fossil remains in rocks may, as Forbes has shown, indicate the formation of these rocks in positions destitute of organic life, such as are to be met with in the extreme depths of the ocean.

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[*] Edin. Phil. Jour., vol. 48.

1179. **The Fossiliferous Stratified Rocks** have been divided into—1. Palæozoic (παλαιὸς, ancient, and ζωὴ, life), or those which contain the earliest fossil remains, including what have been called Transition, Primary fossiliferous, and Grauwacke rocks, and extending up to the Magnesian Limestone, immediately above the Coal measures. 2. Neozoic, including Secondary, extending to the chalk; and Tertiary, extending to the recent deposits. The following tabular view may be given:—

I. Palæozoic.	
Lower Palæozoic	Lower and Upper Silurian.
Middle Palæozoic	Devonian or Old Red Sandstone.
Upper Palæozoic	Carboniferous System, Lower new Red Sandstone, and Magnesian Limestone or Permian System.
II. Neozoic, including—	
a Secondary or Mezozoic.	
Lower Secondary	Upper new Red Sandstone or Triassic System.
Middle Secondary	Liassic, Oolitic, Wealden.
Upper Secondary	Cretaceous.
b Tertiary or Cainozoic.	
Lower Tertiary, or Eocene group.	
Middle Tertiary, or Miocene group.	
Newer Tertiary, or Pliocene group.	
Superficial Deposits, or Pleistocene group.	

1180. **Fossil Plants in Different Strata.**—The plants in these stratified rocks are either of a marine, fluviatile, lacustrine, or terrestrial nature, according to the state of the globe at the period of their deposition. The condition of the strata as regards fossils may depend in some measure on the depth at which they were deposited under the waters of the globe; for Forbes finds that in the present ocean there is, at a certain depth, a zero of animal, and probably of vegetable life. The state of preservation depends much on the nature of the plant in regard to its anatomical structure. Cellular plants, which are easily destroyed, have in a great measure disappeared, while plants which resist well the decomposing action of water and other agents, such as ferns, occur in great abundance. In the Silurian system, the fossils consist chiefly of invertebrate animals. Lignite has been detected by Hugh Miller in the old Red Sandstone of the north, and has been referred to some coniferous plants by Nicol. In the Carboniferous system, fossil plants occur in vast quantity. With the Palæozoic series one great epoch in the Rock formations was concluded, and a change took place so as to usher in the Secondary series. In the new Red Sandstone, the fossil remains are few and local, while in the Oolitic and Cretaceous systems they are more numerous. With the Secondary series of strata a general condition of the globe ended, and a new one commenced with the Tertiary strata. In these we meet with fossil remains nearly resembling or identical with the existing races. The names given to the groups indicate this. In the Eocene group (ἠὼς, *dawn or morning*, and καινὸς, new) we meet with a certain proportion of living shells. In the Miocene (μείων, less,) the number of living species increases, although still less in number than the extinct ones; while in the Pliocene (πλείων, more,) the recent shells outnumber the extinct ones. The differences between the organic contents of one system and another, are in proportion to the interval of geological time elapsed between them; and the older the rocks, the more are the fossils distinct from the plants of the present day. The systems of organic life have been adjusted to the condition of land and sea.

1181. The number of fossil plants known to M. Adolphe Brongniart, in 1836, was 527. In 1845, Goeppert and Bronn stated the number to be 1,792; and as in the 100,000 plants now known to exist in different parts of the globe, a large proportion consists of cellular plants, which would disappear in the process of fossilization, it would seem that the total number of known fossil species bears a considerable proportion to those now existing. Their numerical distribution in the different rocks is stated by Goeppert to be as follows:—

Older and Middle Palæozoic	52
Carboniferous	819
Permian	58
Triassic	86
Oolitic	234
Wealden	16
Cretaceous	62
Tertiary	454
Unknown	11
	1792

From this table, Murchison remarks, it appears that the newer Palæozoic group contains more than half the known species of fossil plants,—a remarkable circumstance when it is considered that the great herbivorous land quadrupeds had no existence before the tertiary period. The small number of plants in the Cretaceous system is probably owing to the depth of the sea in which these formations were deposited.

1182. Among Dicotyledonous fossils there are numerous Amentaceæ, Coniferæ, and Cycadaceæ, besides many doubtful species. Among Monocotyledons, there appear to be plants belonging to Liliaceæ, Smilaceæ, Palmæ, Potameæ, Pandanaceæ, &c. Among Acotyledons there are genera and species belonging to Equisetaceæ, Lycopodiaceæ, and Filices, and a few Marsileaceæ, Musci, and Algæ.

1183. It is impossible in a short treatise like this to allude to many of the fossil species of plants. It will be sufficient to indicate some of the more important genera. The vegetable remains met with in the Silurian and Devonian rocks are few and unimportant, compared with those which characterize the Carboniferous period; and their structure

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* Unger enumerates 2421 fossil species in his work on Fossil genera and species, publishe in 1850.

seems to indicate either that they have been longer exposed to the agency of moving water, or that they are cellular marine species. An exception to this, however, occurs in the Lignite noticed by Miller. It is in the argillaceous and sandy beds of the Carboniferous system we first meet with decided proofs of the existence of land plants. These strata and sands alternate with beds of Coal, a mineral which is of vegetable origin, and which is deposited in various quarters of the globe in hollow troughs, the layers varying from the thickness of a few inches to 10 or 20 feet. It is rare to find coal exhibiting vegetable structure under the microscope; but in certain cases this may be evidently seen. I have seen it in the Arniston coal of this neighbourhood. Some have maintained that each stratum of coal is the product of a peculiar vegetation, frequently different from that which precedes, and from that which follows it. Hence each stratum is often characterized by the predominance of certain impressions. In examining a coal seam, there are frequently evidences of three distinct phases. In the underclay there are roots permeating the mass; then comes the coal, which is either formed out of the plants whose roots are in the clay, or of others which have grown with them, or have been drifted; and lastly, above the coal there is the shale, which appears to have supported a vigorous vegetation. Unger has enumerated 683, and Brongniart 500 plants as belonging to the Coal Measures. The latter is equal to about 1-20th of the number of species now growing on the surface of European soil.

1184. M. Brongniart, from the investigation of the several geological formations, has arrived at the conclusion, that three distinct periods of vegetation can be established. In the most ancient periods, the predominance of acrogenous cryptogamous vegetables (*Ferns* and *Lycopodiaceæ*), later, the predominance of gymnospermous dicotyledons (*Cycadeæ* and *Coniferæ*), without any admixture of angiospermous dicotyledons; and, in the last place, during the chalk formation, the appearance and predominance of angiospermous vegetables, both dicotyledons and monocotyledons, may be considered as characteristic. These differences lead M. Brongniart to recognize three long periods of vegetable growth, which he terms the reign of the Acrogens, the reign of the Gymnosperms, and the reign of the Angiosperms, as indicative of the successive predominance of each of these three great divisions of the vegetable kingdom, rather than the complete exclusion of the others. Each of these three kingdoms is commonly subdivided into many periods, during which traces of the same family and genera are discoverable. These periods comprehend many epochs, during which vegetation does not appear to have undergone any notable changes. Materials are often wanting to establish precisely these subdivisions, either from a want of accuracy in determining the exact geological position of beds enclosing vegetable impressions, or because the division of the various species in the different beds of the same formation has not been carefully established. M. Brongniart proposes the following general division of the fossil kingdom:—

I. REIGN OF THE ACROGENS.
1. CARBONIFEROUS PERIOD.
(Not susceptible of subdivision into epochs in the present state of our knowledge.)

2. PERMIAN PERIOD.
(Forming only one epoch ?)

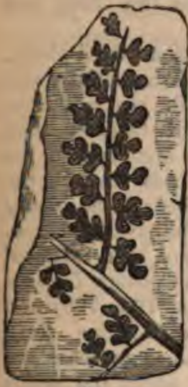
II. REIGN OF THE GYMNOSPERMS.
3. VOSGIAN PERIOD.
(Constituting a single epoch.)
4. JURASSIC PERIOD.
Keupric epoch, Lias epoch, Oolitic epoch, Wealden epoch.

III. REIGN OF THE ANGIOSPERMS.
5. CRETACEOUS PERIOD.
Subcretaceous epoch, Cretaceous epoch, Fucoidian epoch.

6. TERTIARY PERIOD
Eocene epoch, Miocene epoch, Pliocene epoch.

1185. **I. Reign of the Acrogens.**—In this period Acrogens and Gymnosperms are found to have existed simultaneously, the former predominating over the latter in number and size. The number of the Fern family, the great development of the Lycopodiaceæ, are the most prominent characters of this epoch. Other anomalous families belonging to the Gymnosperms are also met with, which differ from actually existing orders.

1186. **Fossil Plants of the Carboniferous System.**—The great mass of fossil plants of this system belong to Acrogenous Cryptogamics and Dicotyledonous Gymnosperms. Some of the plants called Palms, such as *Nöggerathia*, *Flabellaria*, and *Artisia*, are referred by Brongniart to the latter division. Ferns abound in this system, especially in the clays, ironstones, and sandstones. The species are included under the genera *Sphenopteris*, *Pecopteris*, *Neuropteris*, *Odontopteris*, *Cyclopteris*, *Glossopteris*, and *Lonchopteris*. These plants rarely exhibit any traces of fructification, in consequence of only one surface of the fronds being exposed to view, and they are therefore distinguished chiefly by the shape and venation of their fronds. Thus, Sphenopteris (σφὴν, a wedge, and πτέρις, a fern), has a bi-tripinnatifid frond, pinnæ narrowed at the base (cuneate), not adherent to the rachis, lobed, veins bipinnate, somewhat radiating from the base (fig. 793). In Pecopteris (πέκω, I comb), the frond is pinnatifid or bi-tripinnatifid, pinnæ adnate to the rachis, sometimes confluent, a strong primary vein reaching the apex, the secondary veins being nearly straight, simple or forked, rarely pinnate, sori rounded at the end of the secondary veins (fig. 794). In Neuropteris (νεῦρον, a nerve), the frond is pinnate or bipinnate, pinnæ subcordate at the base, distinct from the rachis, strong primary vein vanishing towards the apex, secondary veins oblique, arched, repeatedly dichotomous (fig. 795). Tree-ferns appear to have existed in Britain during the deposit of the coal strata, and to have occupied an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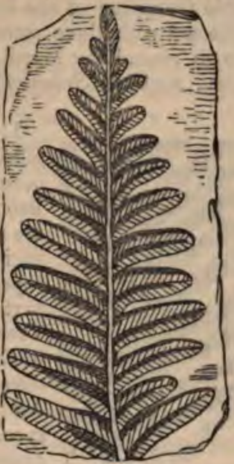
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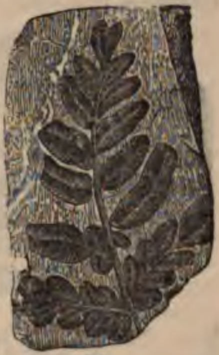
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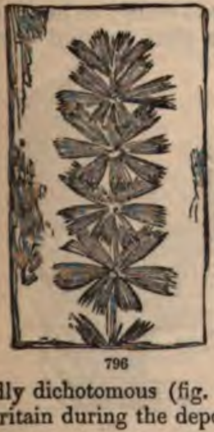
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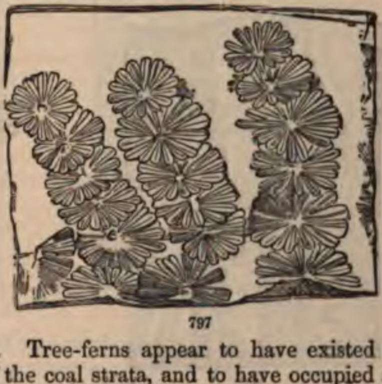
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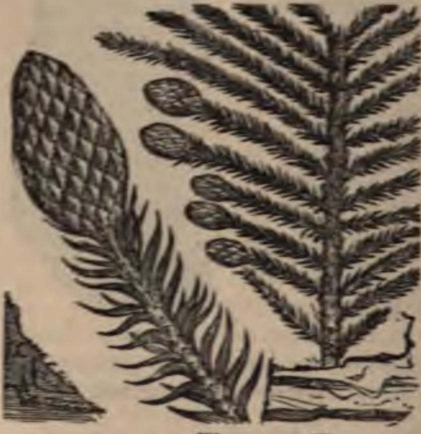
Fig. 793.—Sphenopteris Hæninghausii, a fern of the Carboniferous system.
Fig. 794.—Pecopteris aquilina, another fern.
Fig. 795.—Neuropteris Loshii, another fern.
Fig. 796.—Sphenophyllum dentatum, one of the dubious forms of the Carboniferous system, perhaps allied to Salisburia.
Fig. 797.—Annularia brevifolia, a coal plant, the affinities of which are unknown.

important place in the flora. The stems of these ferns are included under the genus *Caulopteris*. The fronds have not been found attached; but it is probable that some of the fronds found in the coal measures have been connected with these stems. Other plants, considered by some authors as resembling Marsileaceæ, have also been found in certain localities; such as *Sphenophyllum* (fig. 796) and *Annularia* (fig. 797).



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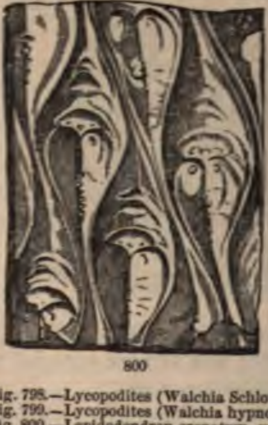
1187. Some fossil plants, allied to Lycopodiums, also occur in the coal measures. Brongniart believes they are more abundant in the ancient beds than in the superior beds of the greater part of the coal formation. These have been included under the genera *Lycopodites* (figs. 798, 799) and *Selaginites*. Some fossil species allied to these are grouped under the genus *Lepidodendron* (λεπίς, a scale, and δένδρον, a tree) (figs. 800, 801). They appear to occupy an intermediate place between Coni-



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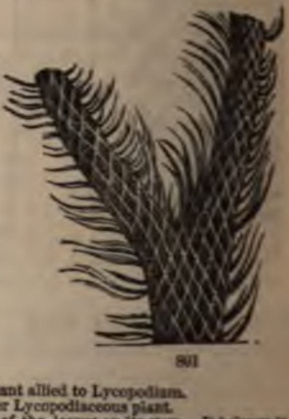

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Fig. 798.—Lycopodites (Walchia Schlotheimii), a plant allied to Lycopodium.
Fig. 799.—Lycopodites (Walchia hypnoides), another Lycopodiaceous plant.
Fig. 800.—Lepidodendron crenatum, with the scars of the leaves on its stem. It belongs to a family of plants apparently intermediate between Coniferæ and Lycopodiaceæ.
Fig. 801.—Lepidodendron elegans, with its dichotomous trunk, and linear acute leaves.

ycopodiaceæ. Their leaves are arranged in the same
me of the Coniferæ, and their scars are similar. Their
urcate like Lycopodiaceæ. They occur in the form
us trunks, 20 to 45 feet high, with linear or lanceolate
801) like those of some species of Lycopodium and
he stem consists of a thin cuticle, a double cellular
w vascular cylinder, and a pith. The tissue in the outer
double cellular zone is arranged like that of ferns, the
nder is about ⅛ of an inch thick, and consists of polygonal
d with lines, while the pith is composed of fusiform cells.
e marked with rhomboid and orbicular scars (fig. 800).
ike fruit is said to occur in a fossil form called *Lepidos-*
under this name, as well as that of *Strobilites*, the fruit of
nt plants seems to be included. *Lepidophyllum* is said to
f some Lepidodendron, and *Ulodendron* is an allied genus.
gmaria (στίγμα, a mark or impression) is a fossil genus,
f which abound in the coal measures. They occur gen-
bed called the Underclay. *Stigmaria ficoides* (fig. 802)
on species. It consists of a dome-shaped mass sending
d and pitted branches, which divide dichotomously, and
30 feet. Slender processes are given off, which appear
hollow (fig. 802). These processes (called fistular roots),

802

803

ngled mass traversing the argillaceous lower bed in every
n Stigmarias three tissues are met with, vascular tissue
inner part of the cylinder, ligneous forming the wood,
tissue forming a broad cortical zone, as well as the central

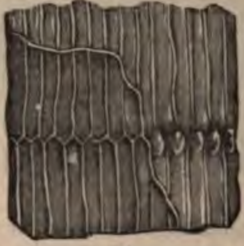
naria ficoides; a branch giving off fistular leaves, which traverse the Underclay

laria pachyderma: the stem marked with scars, and fluted longitudinally.

portion or pith. Some think that the stores of fossil fuel in England and America are mainly due to the presence of this plant. There are no plants of the present day which resemble Stigmarias. Stigmaria ficoides has been found to be the rhizome and roots of a species of Sigillaria. Specimens of the latter have been discovered standing erect. and connected with Stigmarias.

1189. *Sigillaria* (*sigillum*, a seal,) is another plant which appears to have aided in the formation of coal. It occurs in the form of compressed stems, attaining a height of 40 to 50 feet, and a breadth of 5 feet. The stems are fluted longitudinally, and marked at regular intervals by single or double scars, the remains of the leaf insertions (fig. 803). Some suppose Sigillarias to be allied to Tree-ferns, others to Coniferæ. Brongniart says they resemble Zamia integrifolia, and appear to predominate in the middle and superior beds of the coal formations. King thinks that they are intermediate between Ferns and Cycadaceæ, that the fronds called Neuropteris constitute their foliage, while Stigmarias are their roots. They have a medullary sheath in the shape of apparently isolated bundles, and vessels intermediate between true spiral and scalariform. The bark is said to be composed of two different layers, thus giving rise to different impressions. The furrows or fluted marks are due to the arrangement of the leaves on the stem. King says, that if in imagination we delineate a channelled stem of any height between 12 and 100 feet, crowned with a pendant fern-like foliage, furnished with wide spreading thickly fibrilled roots, and growing in some densely-wooded swamp of an ancient Mississippi, we will then have formed a tolerably close restoration of a Sigillaria vegetating in its true habitat.

1190. *Calamites* (κάλαμος, a reed), another coal fossil plant, occurs in the form of jointed fragments, originally cylindrical, and perhaps hollow, but now crushed and flattened (fig. 810). The stems are branched (fig. 805), and there appears to have been a distinct wood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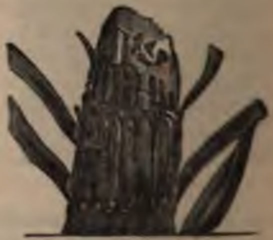
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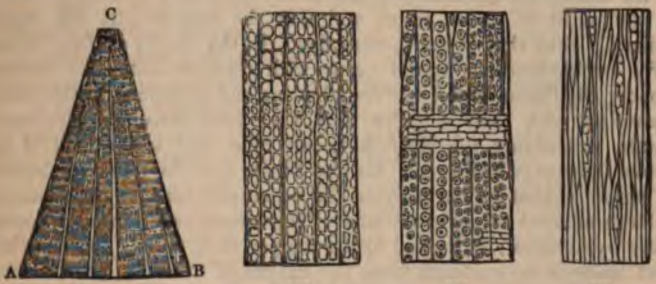
Fig. 804.—Calamites Suckovii, composed of jointed striated fragments having a bark.
Fig. 805.—Calamites cannæformis giving off branches.

and bark. Their internal cavity seems to have been separated by horizontal partitions at the articulations, the intervals between the articulations becoming smaller towards the ends of the branches. Both stems and branches are ribbed and furrowed (fig. 804). Some refer the numerous species of Calamites to Equisetaceæ, but the presence of wood and bark has led others to place them among Dicotyledons.

Some interesting fossil Coniferæ, included under the names *Pinites* and *Araucarites*, are found in the carboniferous sandstone, as in Craigleith Quarry, near Edinburgh. The specimens found in Craigleith have been referred to *Pinites Withami* and *medullare* of Lindley and Hutton (*Araucarites* of Goeppert, and *Dadoxylon* of Endlicher). Some of these seem to be allied to the Araucaria tribe; for instance to Eutassa excelsa, the Norfolk Island Pine. Their wood, under the microscope, exhibits the punctated appearance and other characters of Coniferæ (figs. 806-809), and the disks are often in two or more rows (fig. 808).



806 807 808 809

Some specimens have been found upwards of 70 feet long. These Coniferæ seem not to have been associated with the Sigillarias and the other plants which abound in coal seams. They probably flourished in the neighbourhood, and were at times transported to these localities. A peculiar kind of fossil fruit called *Trigonocarpum*, resembling that of a Palm, has been found in some of the carboniferous sandstones. *Nöggerathia* and *Flabellaria* have been referred to species of Palms, but Brongniart considers them as Cycadaceous. *Lyginodendron* (λύγινος, wicker work,) is a peculiar coal fossil discovered by the Rev. Mr. Landsborough in Ayrshire, and described by Mr. Gourlie. Its im-

Figs. 806-809.—The structure of wood in recent Coniferæ, to illustrate the appearances presented by some fossil woods.

Fig. 806.—Transverse section of a piece of Coniferous wood, of the natural size.

Fig. 807.—A section of the same wood seen under the microscope. The medullary rays and woody tubes seen without any large porous vessels.

Fig. 808.—Longitudinal section of the same, in the direction B C, magnified. A medullary ray seen crossing the woody tubes, which are marked by disks, in one or more rows.

Fig. 809.—Section of the same in the direction A B, perpendicular to the medullary rays, which are seen at intervals between the woody fibres.

pression consists of rounded narrow twigs, which cross each other like the parts of an osier basket. *Sternbergia* is a peculiar fossil, consisting of horizontal plates, which are held together by some connection in the axis. Some look upon it as allied to Dracæna; others regard it as fossilized discoid pith. It may be remarked, in general, that the Carboniferous flora is uniform, or nearly so, in all parts of the globe where carboniferous fossils have been obtained, viz. the whole of western, northern, and eastern Europe, North America, from Alabama to Melville Island, various districts of Asia, Eastern Australia, and Van Diemen's Land, and probably the Asiatic Islands.

1191. As the great mass of fossils in the coal formation consists principally of ferns, Brongniart has been led to draw conclusions as to the climate of the globe, at the time when the coal fossils grew. Ferns of the present day thrive best in a moist insular climate, and many of them occur in tropical climates. Hence Brongniart conjectures that at the coal epoch the surface of the earth consisted of a series of islands in the midst of a vast ocean, and that the temperature was higher generally than that of the present day. In the forests of these islands lofty Lepidodendrons would occur with their delicate and feathery fronds; Sigillarias, with their fluted stems and enormous matted roots; Calamites, with their singular branches; Tree-ferns and Coniferous plants, resembling the Norfolk Island Pine, and towering 100 feet above the rest of the forest. He also thinks that the immense deposits of carbon at that epoch, warrant the conclusion that the air contained a large amount of carbonic acid. These conclusions are, of course, mere hypotheses. In regard to the temperature, it may be remarked, that there is no evidence from the nature of the flora, of a marked increase of temperature at the coal epoch. In New Zealand, which is in a latitude the same as that of a great part of Europe, a very large proportion of the vegetation consists of Acrogenous plants. Ferns and their allies, in that country, cover immense districts, replacing the grasses of other countries, and giving a marked character to all the open land. Some of the ferns attain a height of 30 or 40 feet, and occur in groups. Hemitelia capensis too, a Tree-fern found at the Cape, was also seen by Gardner, at an elevation of 6,000 feet, on the Organ mountains, thus showing a capability of enduring a great range of climate, and warning us against hasty conclusions on the subject of the temperature of the world at the coal epoch.

Dr. Hooker thinks that the prevalence of ferns may be regarded as a probable evidence of the paucity of other plants, and the general poverty of the whole flora which characterized the formation. He is led to these conclusions from observing the mode in which the ferns in Van Diemen's Land and New Zealand monopolize the soil, choking plants of a larger growth on the one hand, and admitting no undergrowth of smaller species on the other. In New Zealand he has collected 36 kinds of ferns on an area not exceeding a few acres; they gave a most luxuriant aspect to the vegetation, which presented scarcely a dozen flowering plants and trees besides.

1192. Some have supposed that the plants of the coal fields have been drifted into basins, others that they grew in the spots where they are now found. Beaumont thinks that all the vegetables which are now converted into coal, grew in swampy islands, covered with a luxuriant vegetation, which accumulated in the manner of peat-bogs; that those islands having sunk beneath the ocean, were there covered with sand, clay, and shells, till they again became dry land, and that this operation was repeated in the formation of each bed of coal. The occurrence of stems of trees in an erect state (fig. 810), appeared to him to confirm the view that the trees were in situ. Ansted says, that although many trees are found in the coal measures in an erect or highly inclined position, there is no reason for believing that they grew on the spot where they are met with. He rather thinks that they have been caught or stopped in their passage down a rapid stream, and, like the snags in some of the great American rivers, have been detained till the lower portion was firmly embedded in the rapidly forming sandstone. The embedding of stems in strata of sandstone, is similar to what Gardner saw near the mouth of the Rio San Francisco, where

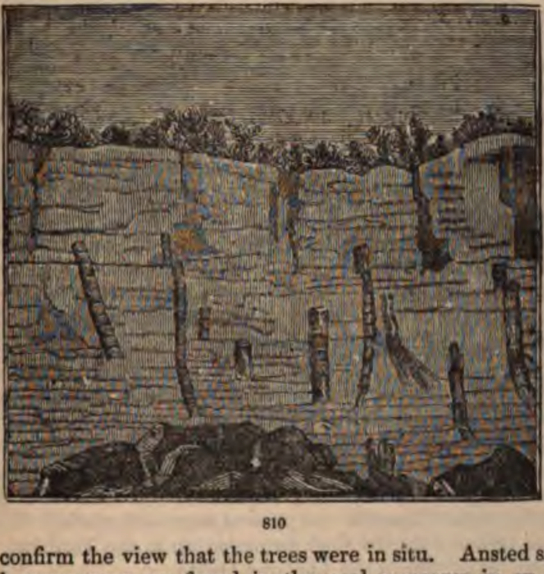


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Fig. 810.—Vertical stems of fossil trees, Calamites chiefly, found in the Coal measures of Treuil, near Saint Etienne.

coco-nut trees were found with their stems immersed to the depth of 50 feet or more in the embankment of sand which stretches along the shore. Phillips remarks, that the condition of the plants which compose the coal, the general absence of roots, the fragmentary state of the stems and branches, the dispersed condition of the separable organs, all confirm the conclusion that the plants have been swept down from the land on which they grew by watery currents, often repeated, and deposited in basins and large estuaries of the sea, or perhaps rarely in lakes of fresh water.

1193. The nature of the vegetables which appear peculiar to the Permian period, M. Brongniart believes is far from being determined in a positive manner, in consequence of the uncertainty which is attendant on the period of certain geological formations. On account of these doubts, M. Brongniart indicates three separate floras. 1*st*, The Flora of the bituminous slates of Thuringia, composed of Algæ, Ferns, and Coniferæ. 2*d*, The Flora of the Permian sandstones of Russia, which comprehends Ferns, Equisetaceæ, Lycopodiaceæ, and Nöggerathiæ. 3*d*, The Flora of the slates of Lodève, which is composed of Ferns, Asterophyllites, and Coniferæ. It is observed that many of the fossils met with in the bituminous slates of Thuringia appear to be marine plants, and that hitherto no species common to these localities has been found.

1194. **II. Reign of the Gymnosperms.**—In the Carboniferous period, the Acrogenous Cryptogams were found to predominate, while the Gymnospermous Dicotyledons were less numerous. In this reign, on the other hand, the Acrogens are less numerous, and the Gymnosperms almost equal them in number, and ordinarily surpass them in frequency.

The reign of the Gymnospermous Dicotyledons is divided into two periods: the first, in which the Coniferæ predominate, while the Cycadaceæ scarcely appear; the second, in which the latter family preponderates as regards the number of species, and the frequency and variety of generic forms. Cycadaceæ occupied a more important place in the ancient than in the present vegetable world. They extend more or less from the Coal formation up to the Tertiary. They attain their maximum in the Lias and Oolite.

1195. Brongniart believes the Vosgesian period not to have been of long duration, and to comprehend only the variegated sandstone, properly so called, or the Red Sandstones and conglomerates of the Triassic system. It is characterized by the existence and presence of peculiar ferns, such as Anomopteris and Crematopteris; while Gymnospermous plants are represented by the genera Voltzia and Haidingera, Zamites, Ctenis, Æthophyllum, and Schizoneura. Sigillarias and Lepidodendrons disappear. Stems of arborescent ferns are frequently met with.

1196. The Jurassic period of Brongniart includes—1. The Keupric

Epoch, whose vegetable forms consist of Algæ, Ferns and Equisetaceæ, Cycadeæ and Coniferæ, and also of two doubtful Monocotyledons (Palæoxyris and Preisleria). 2. The *Lias Epoch*, whose essential characters are the great predominance of Cycadeæ, and the existence among the ferns of many genera with reticulated venation. 3. The *Oolitic Epoch*, which furnishes Algæ, Ferns, Marsileaceæ, Lycopodiaceæ, Equisetaceæ, Cycadeæ, and Coniferæ. The distinctive characters of this epoch are—amongst the Ferns, the rarity of reticulated venation so common in the Lias; the greater approach of the Cycadeæ in character to those now existing; and the greater frequency of the Coniferæ. 4. The *Wealden Epoch*, which is characterized in the north of England by the abundance of the Fern called Lonchopteris Mantellii, and in Germany by the predominance of the Conifer, denominated Abietites Linkii, as well as by numerous Cycadaceæ.

1197. **Fossil Plants of the Secondary Strata.**—The plants of the Secondary series of strata are thus shown to be different from those of the Carboniferous system. The Stigmarias, Sigillarias, and Lepidodendrons cease, and are replaced by ferns and their allies. Plants of the Zamia tribe occur along with some Coniferæ. The pinnated frond called *Pterophyllum* (fig. 811), appears to belong to a Cycadaceous plant allied to Zamia, while *Voltzia* (fig. 812) and *Peuce* seem to be Coniferous genera. In the secondary formations, generally, there are no true coal fields, although carbonaceous matter, in the form of imperfectly bituminized lignite, is found deposited occasionally. Notwithstanding the absence of true coal, the sandstones and shales of the Oolitic system contain numerous fossil plants, which in their form and character seem to be a transition between the Palæozoic flora, and that of more recent formations. In the upper Oolite at Portland, there is a bed of earthy brown matter, about a foot in thickness, commonly known as the Dirt-bed, in which there is an assemblage of silicified stumps of large trees (fig. 813). They are generally in an erect position (fig. 814), and appear to be in situ. They are probably Cycadaceæ. Plants of this natural family, in the form of

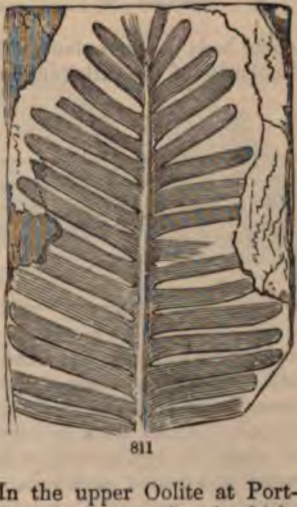

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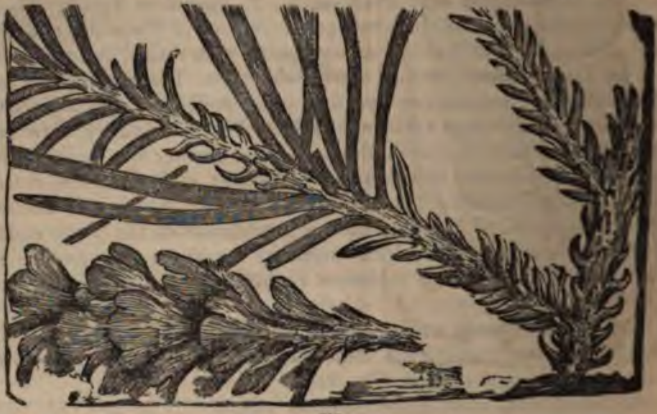
Fig. 811.—Pterophyllum Pleiningerii, apparently the frond of a fossil Cycadaceous plant allied to Zamia.

Zamites (fig. 816), *Mantellia* (fig. 814), *Cycadites*, and *Pterophyllum* (fig. 815), may be said to characterize the fossil flora of the older oolite beds. These plants take the place of the Lepidodendrons and Sigillarias of the carboniferous period. The stems are found without any leaves attached, but some suppose that the fronds called *Otopteris* are the leaves of some of the species. The occurrence of these tropical forms seems to indicate a warmer climate than now exists in Britain. There are 6 existing genera of Cycadaceæ (¶ 1047). Two of these are represented in figs. 817, 818, showing the forms of the stems and leaves or fronds. There are 5 fossil ones according to authors. The fossil Cycadaceæ known up to 1845, and distinguished by specific names, amount, according to Goeppert, to 78. Amongst these are 9 stems or stipes, 65 fronds, and 4 fructifications. The genera are :—



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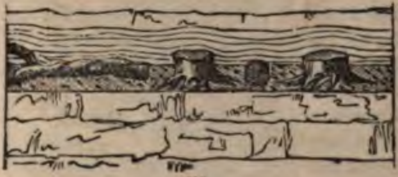

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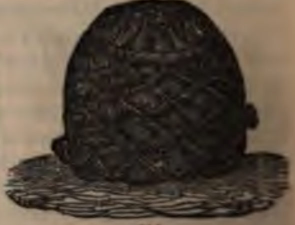

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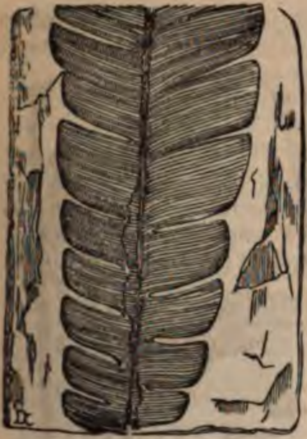
Fig. 812.—Voltzia heterophylla, one of the fossil coniferæ of the Triassic system.

Fig. 813.—The Dirt-bed of the island of Portland, containing stumps of fossil Cycadaceæ in an erect position.

Fig. 814.—Mantellia nidiformis (Cycadeoidea), one of the silicified Cycadaceæ of the Portland Dirt-bed.



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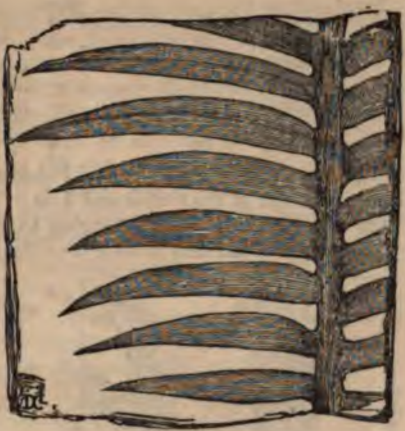

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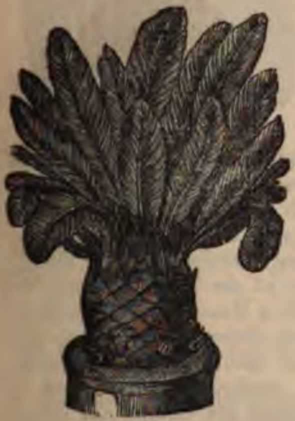

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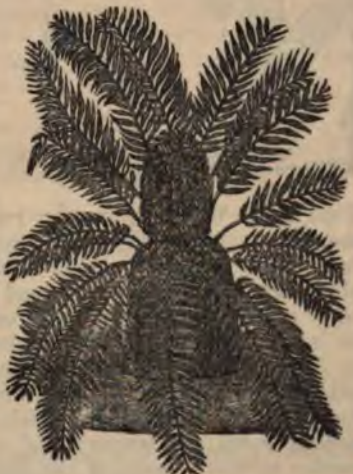

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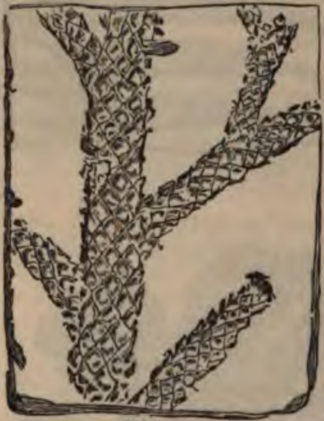
Fig. 815.—Pterophyllum Williamsoni, the frond of one of the fossil Cycadaceæ.
Fig. 816.—Zamites. One of the fossil Cycadaceæ.
Fig. 817.—Cycas revoluta, one of the species of Cycas of the present flora of the globe, with its scale-like stem and pinnate fronds.
Fig. 818.—Zamia pungens, one of the Cycadaceæ at present existing on the globe.

		Stems.	Fronds.	Fructification.
Cycadites,	11	4	7	—
Zamites,	28	5	23	—
Zamiostrobus,	4	—	—	4
Pterophyllum,	23	—	23	—
Nilsonia,	12	—	12	—
	78	9	65	4

To this some add Mantellia and Palæozamia. The greater number of these is found in the Oolite and Lias. In the inferior Oolites are also seen peculiar Coniferæ, belonging to the genus *Brachyphyllum* (fig. 819), and a plant said to be a true Equisetum (fig. 820). The fossil Flora of the Wealden formation resembles, in many respects, that of the Oolitic system. Fronds of ferns, leaves of Coniferæ (*Sphenophyllum*), and of Cycadaceæ, occur along with some Fucoids. There are also silicified coniferous trunks, and two peculiar genera called *Clathraria* and *Endogenites*. The former is an arborescent plant, having its bark formed by the union of the bases of the leaves, and covered by distinct scales. The latter is apparently a Monocotyledon, perhaps allied to Palms. Some fruits, resembling those of Palms, are also found. In the Cretaceous system, there occur fossilized Dicotyledonous leaves and fragments of wood, marked by perforations of marine animals. Some of the Dicotyledons are Coniferous, others Cycadaceous.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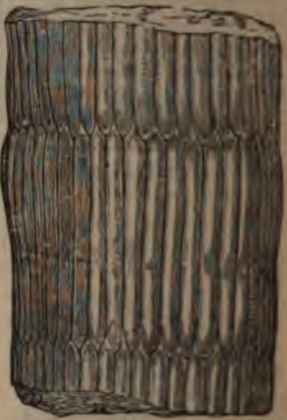
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1198. **III.—Reign of the Angiosperms.**—The dominating character of this last transformation of the vegetation of the globe is the appearance of Angiospermous Dicotyledons, plants which constitute more

Fig. 819.—Brachyphyllum, a Coniferous genus of the Oolitic System.
Fig. 820.—Equisetum columnare, a fossil species of the Oolite.

than three-fourths of the present flora of the globe. In this reign, Brongniart distinguishes two great periods—1st, The Cretaceous period, a kind of transition period between the reign of Gymnosperms and Angiosperms. The chalk flora is characterized by the Gymnosperms almost equalling the Angiospermous Dicotyledons, and by the existence of a considerable number of Cycadaceæ, which do not appear in the Tertiary period. The genus Credneria is one of the characteristic ferns. 2d, The Tertiary period, presenting all the characters arising from the predominance of Angiospermous Dicotyledons and Monocotyledons. The *Fucoidean Epoch*, which seems to form the natural limit between the cretaceous and tertiary periods, is characterized by deposits rich in Algæ, of a very peculiar form. M. Brongniart has not found land plants mingled with these marine species, nor does he believe that fossil woods have been met with.

1199. The Tertiary period is characterized by the abundance of Angiospermous Dicotyledons, and of Monocotyledons, more especially Palms. Angiosperms in the Tertiary period are found greatly to exceed Gymnosperms. At the Cretaceous epoch, Cycadeæ and Coniferæ, allied to the genera inhabiting tropical regions, existed; during the Tertiary period, the Cycadeæ appear to have been completely wanting in Europe. M. Brongniart, having divided the Tertiary period, as regards plants, into the Eocene, Miocene, and Pliocene, believes that we shall find the number of species in the great divisions are thus distributed in these three Floras:—

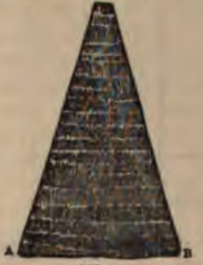
Classes and Sub-Classes.	Eocene Epoch.	Miocene Epoch.	Pliocene Epoch.
Thallogenæ	16	6	6
Acrogenæ	17	4	7
Monocotyledones ...	33	26	4
Dicotyledones—			
Gymnospermæ...	40	19	31
Angiospermæ ...	103	78	164
	209	133	212

In the Eocene formation the fossil fruits of the Isle of Sheppey increase the number of Phanerogamous plants.

1200. With regard to the characters drawn from vegetable forms during these three epochs, the most remarkable appear to be—1st, In the *Eocene* period, the predominance of Algæ and marine Naiadaceæ, such as Caulinites and Zosterites; the existence of a great number of extra European forms, especially of fruits, such as Nipadites, Leguminosites, Cucumites, and Hightea. 2d, In regard to the *Miocene* epoch, the abundance of Palms, such as Flabellaria and Phœnicites, and other plants of warm climates, with others of temperate and cold climates, such as Amentiferous forms. 3d, The *Pliocene* epoch is known by the great predominance and variety of Dicotyledons, the rarity of Monocotyledons, and, above all, the absence of Palms, as well as the general analogy of the forms of these plants with those of the temperate regions of Europe, North America, and Japan.

1201. **Fossil Plants of the Tertiary Strata.**—From these observations it may be inferred that with the Chalk formation, the ancient condition of organized beings appears to have ended, and a new one to commence in the Tertiary series. The plants of the Palæozoic and Secondary series are all extinct. Those which occur in the tertiary are totally different from all that have previously appeared. With the chalk, Ansted says, we close, as it were, one great volume of the history of animated creation. Everything up to this point belongs to the past; everything on this side of it may be ranked among indications of the present. New forms, new types of organization, corresponding to different habits and altered circumstances, now replace those which have passed away. The conditions under which animals and vegetables lived were changed, and a new epoch commenced upon the earth.

1202. Except a few doubtful fossils of the lowest organization, there are none common to the secondary and tertiary periods. The tertiary series are well seen in the south of Europe, Asia, and America. In Britain the tertiary deposits are met with in the London clay, in Hampshire and the Isle of Wight, the Suffolk and Norfolk Crag, and



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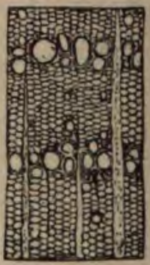

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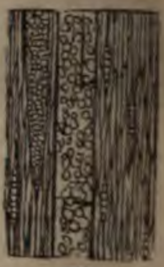

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Figs. 821-825.—Structure of ordinary Dicotyledonous stems, to illustrate the appearances presented by some tertiary fossil woods.

Fig. 821.—Portion of a Dicotyledonous (Exogenous) stem cut transversely. Natural size.

Fig. 822.—Section of the same magnified, to show the occurrence of large porous vessels. The ordinary Dicotyledons differ in this respect from Coniferæ.

Fig. 823.—Longitudinal section of the same in the line A B, perpendicular to the medullary plates, showing a large porous vessel, and the rays appearing here and there among the woody tissue.

in the Till of the Clyde. The London clay contains numerous fruits belonging to many hundred species of plants. The first tertiary land of which we have knowledge, seems to have been richly clothed with plants. The strata are, generally speaking, rich in fossils. The stems

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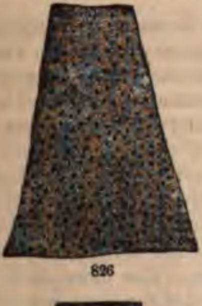
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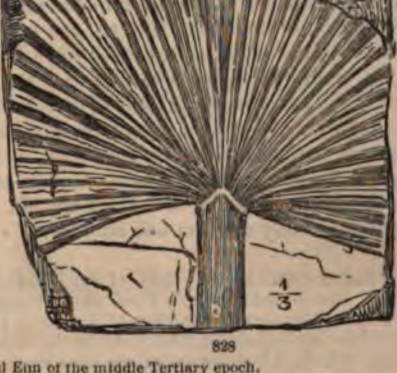

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Fig. 824.—Leaf of an unknown fossil Elm of the middle Tertiary epoch.
Fig. 825.—Leaf of Comptonia acutiloba, an Amentaceous plant of the same epoch.
Fig. 826.—Section of a recent Palm stem, to show its structure. The dark dots marking vascular bundles in the midst of cellular tissue.
Fig. 827.—A portion of the same magnified, to show the vascular bundles.
Fig. 828.—Palmacites Lamanonis. Leaf of a Monocotyledon resembling a Palm.

and leaves appear to be those of Dicotyledons, little differing from the plants of the present day (figs. 821-825). In the brown coal of this series, the structure of the wood is evident, and distinctly exogenous (figs. 821-823), and there are often associated with it leaves of Poplars, Elms (fig. 824), and other forest trees. The fossil plants of the Isle of Sheppey have been examined by Bowerbank, and have led to the determination of several hundred species of plants, all of them extinct, and all resembling those of warmer climates;—fruits of *Nipadites* (*Pandanocarpum*), a fossil plant, allied to Nipa, one of the Pandanaceæ; *Hightea*, a five-seeded fruit, probably Malvaceous; also the fruit of a Proteaceous plant, and of species allied to Canna, Cucumber, and the Leguminosæ and Coniferæ of the present day. To some of them the names of *Cupanoides*, *Wetherellia*, *Cucumites*, and *Mimosites*, have been given. In some of the tertiary formations there occur pieces of wood, which present the structure of that of Pepper-plants and of Palms (figs. 826, 827), and there are also leaves which have the flabelliform appearance of Palm leaves, included under the name of *Palmacites* (fig. 828). Specimens allied to Chara are also found, with their fructification denominated *Gyrogonites*. Above the tertiary strata, and forming a continuous series with the formations of the present day, occur the superficial deposits or the Pleistocene (πλεῖστος, most,) group. They are ascribed to the violent action of water, and are sometimes called Diluvial.

1203. There have thus occurred in this earth successive deposits and creations of plants and animals. These deposits have been variously altered and distributed, but all have proceeded upon one grand and harmonious principle, and all speak the same language. They tell us of changes which have taken place during the preparation of this world for the abode of man, the noblest of the Great Creator's works. Many are afraid to enter upon the investigations of Palæontology, from a mistaken idea that they are at variance with Scripture. We need not fear, however, that in prosecuting our scientific researches, we shall ever arrive at a point where the knowledge of nature will be found at variance with the truths of Scripture. The more each is studied, the more shall we find occasion to admire the harmony that subsists between them, and the beautiful light of illustration which they reciprocally shed on one another.

For further details on the subject of Fossil Botany, consult Brongniart's Plantes Fossiles, Hutton and Lindley's Fossil Flora, Witham on Fossil Plants, Goeppert's Fossil Ferns, Goeppert on the Flora of the Brown Coal Formation, in Arbeiten der Schlesichen Gesellschaft for 1847, and in the Quarterly Journal of the Geological Society, Vol. V., King's Papers on the Coal Fossils in the Edinburgh Philosophical Journal, Hooker's Papers in the Report of the Geological Survey of Great Britain, Unger, Genera Plantarum fossilium, and Chloris protogea; besides Geological works, such as Lyell's and Ansted's Geology.

APPENDIX.

I.—ON THE USE OF THE MICROSCOPE IN BOTANICAL RESEARCHES.

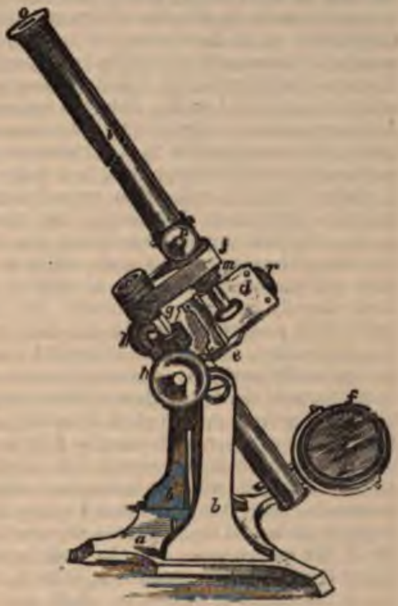
1204. The Microscope is a most important instrument in education. It is essential for the due understanding of the structure and physiology of plants. The study of the microscopical structure of organized bodies is termed *Histology* (ἱστος, a web or tissue, and λογος, discourse). Dr. Carpenter remarks:—"The universe which the microscope brings under our ken, seems as unbounded in its limit as that whose remotest depths the telescope still vainly attempts to fathom. Wonders as great are disclosed in a speck, of whose minuteness the mind can scarcely form any distinct conception, as in the most mysterious of those nebulæ, whose incalculable distance baffles our hopes of attaining a more minute knowledge of their constitution. And the general doctrines to which the labours of microscopists are manifestly tending, in regard to the laws of organization and the nature of vital action, seem fully deserving to take rank in comprehensiveness and importance with the highest principles yet attained in physical or chemical science. It is by pursuing, by the aid which the microscope alone can afford to his visual power, the history of the organic germ, from the simple and homogeneous form which seems common to every kind of living being,—either to that complex and most heterogeneous organism which is the mortal tenement of man's immortal spirit, or only to that humble Protophyte or Protozoon, which lives, and grows, and multiplies, without showing any essential advance upon its embryonic type, that the physiologist is led to the grandest conception of the unity and all-comprehensive nature of that creative design, of which the development of every individual organism, from the lowest to the highest, is a separate exemplification, at once perfect in itself, and harmonious with every other." The microscope (μικρὸς, small, and σκοπεω, I see) is an instrument for enabling the eye to see distinctly objects which are placed at a very short distance from it, or to see minute objects that would otherwise be invisible. It has been used with great success in the examination of vegetable structure. To it we are indebted for a knowledge of the various vessels and cells which enter into the composition of the different parts of plants, of the circulation of fluids, and of ciliary movements, as well as for the facts connected with the development of the embryo. It is an instrument, however, which requires to be used cautiously; and the conclusions drawn from it ought to be carefully weighed, more especially when the observations have been made with high magnifying powers.

1205. **Lenses.**—Before proceeding to notice the construction of simple and compound microscopes, it will be advantageous to notice the different kinds of lenses used, and the sources of error which require to be guarded against in their preparation. The chief forms of lenses used are, the *double-convex*, with two convex faces; *plano-convex*, with one face flat and the other convex; *double-concave*, with two concave faces; and *plano-concave*, with one flat and one concave face. Sometimes, also, a *meniscus* is used, with a concave and a convex face, and a sharp edge. Convex lenses with sharp edges cause parallel rays to converge; while concave lenses with flat edges cause them to diverge. The lenses used in microscopes are chiefly convex—the concave lenses being employed to make certain modifications in the course of the rays passing through convex lenses, whereby their performance is rendered more exact. The magnifying power of a single lens is its focal length. The principal focus is the point to which parallel rays converge after reflection or refraction. The focus of a double convex lens is at half the distance of a plano-convex, having the same curvature on one side. Ten inches is the mean focal length of the human eye. In the use of ordinary lenses, there are sources of error from the form of the lens, and the nature of the material of which it is made. When parallel rays fall on a double-convex or a plano-convex lens, they are brought into a focus at a certain distance: but it is found that no lens with a spherical surface can bring the rays of light coming from one point exactly into the focus at another point. Hence arises what is called *spherical aberration*. In this kind of aberration, the objects at the circumference of the field of the microscope are not in focus at the same time as those in the centre. Moreover, the material of which the lens is made, acts differently on the different portions of each ray, and separates the white light into different colours, which have various degrees of refrangibility. This gives rise to *chromatic* (χρῶμα, colour) *aberration*. To remedy these defects, certain combinations of glasses have been adopted, so that the light traversing one lens through the centre may pass through near the margin of another. The confusion produced by these aberrations may be greatly lessened by diminishing the pencil of light; for instance, by employing a stop or diaphragm, which lessens the aperture of the lens, and cuts off the peripheral rays. In lenses of low power, such as are used in the simple dissecting microscope, these aberrations will not cause much confusion. It is only when high powers are required that these aberrations must be done away with, the aperture being increased without interfering with definition. The invention of Wollaston's doublet with two lenses, and Holland's triplet with three, was with the view of diminishing, as far as possible, these aberrations. In this, however, they were not successful, for coloured images were still produced. Their lenses were constructed of the same kind of material: and it was afterwards found that in order that lenses might present the object uncoloured, or be what is called *achromatic* (α, privative, and χρῶμα colour), it was necessary to use glasses of two different densities. Achromatic lenses, or such as are nearly free from aberration, are constructed by placing together glasses of different dispersive powers, and of different forms. The usual achromatic consists of a double-convex lens made of plate or crown-glass, and a plano-concave, made of flint-glass fitted accurately to it, and cemented by Canada balsam. Sometimes three lenses are used, a double concave of flint-glass, placed between two double convex of crown-glass, and ground to certain curvatures; and in that case they cannot be cemented. The most perfect combination of lenses, for high powers, consists of eight distinct lenses:—In front, a triplet of two plano-convex lenses of crown-glass, with a plano-concave of dense flint-glass between them; next, a doublet composed of a double convex lens of crown-glass, and a double concave of flint; and at the back, another triplet of two double convex lenses of crown, with a double concave of flint between them. By this combination, an angular aperture of 170° has been obtained with an objective of $\frac{1}{12}$th of an inch focus. This is about the limit; for 10° more would bring the rays to a straight line.

1206. **Microscopes** are of two kinds—Simple and Compound. By the *Simple microscope*, objects are viewed through a single lens, or through two or three lenses placed together, so as to form doublets or triplets. The glass is arranged so that it can be brought over the object, and adjusted, by means of a rack and pinion, or by some other contrivance, to its exact focal distance, the object, when opaque, being seen by light thrown from above, and when transparent, by light transmitted from below. This instrument, when used with single lenses or doublets, is the best for ordinary botanical investigations, more especially for dissections. The combination of three lenses approaches too near the object to be easily used. A very high power may be obtained by means of the lenses termed Coddington's and by doublets formed of plano-convex glasses. The chief objections to the simple microscope are the fatigue attendant on long-continued investigations, and the small field of view. In the simple microscope, glasses of the following focal lengths may be employed—viz., $1\frac{1}{2}$ inch, $\frac{3}{4}$, $\frac{1}{2}$, $\frac{1}{4}$; and, if very minute objects are to be examined, of $\frac{1}{10}$, $\frac{1}{30}$, or $\frac{1}{40}$ of an inch.

1207. In the *Compound microscope* there are two sets of lenses,—the one called the *object-glass* or objective, the other the *eye-piece* or ocular. The first receives the rays from the object, and bringing them to new foci, forms an image, which the second treats as an original object, and magnifies it just as the single microscope magnified the object itself. The image is inverted, but this may be remedied by making the rays pass through another set of lenses in the tube of the microscope, called the *erector*. In the construction of the object-glasses, great care is taken to render them achromatic. Those made by the most eminent London makers consist of two or three compound lenses, which cannot be used separately, but are fixed together in a tube. In the case of high powers, the object-glasses are also provided with an adjustment for the thickness of the glass covering the object to be viewed. This adjustment makes up for the refraction caused by the passage of light through thin glass of different thickness, and is accomplished by altering the distance between the second and third pair of lenses in the object-glass. This adaptation is especially necessary in the case of a glass with a large angle of aperture. In Ross's microscope, when the mark on the cylinder coincides with the longer mark on the tube of the objective, the adjustment is perfect for an uncovered object; when the coincidence is with the short mark, the proper distance is obtained to balance the aberration produced by glass $\frac{1}{100}$ of an inch thick. The eye-piece, also, must be so formed as to be free from error. That used is called Huyghens', and consists of two plano-convex lenses with their plane sides towards the eye, and placed at a distance apart equal to half the sum of their focal lengths, with a diaphragm inserted midway between the lenses. In this eye-piece, the lens next the eye is called the eye-glass, the other the field-glass. By the Huyghenian or negative eye-piece the object is seen inverted. The Ramsden or positive eye-piece consists of two plano-convex glasses, with the convex surfaces directed towards each other; by it objects are seen erect, and it is used as a micrometer eye-piece, that is, for measuring objects. (¶ 1209.) The eye-pieces supplied with the best microscopes are usually three; and they are so constructed, that, with each of the object-glasses, they give a certain amplification of the object, the powers being in the proportion of 1, 2, and 3, or 1, 1½, and 2½. In the best microscopes there is also an *achromatic condenser* or eclairage, through which the light reflected from the mirror passes. The amplification by means of an eye-piece in the compound microscope enables us to use an object-glass of a lower power than would otherwise be necessary. This kind of microscope, when well constructed, gives a flat and colourless picture of the object, with clearness of definition. The observer can use it for a length of time with less fatigue than when employing the simple microscope. Weak eye-pieces and strong object-glasses are to be recommended. The eye-piece does not add either clearness or distinctness to the object, and when it is very powerful the field of view becomes too small to take in the whole image formed by the object-glass; for the magnitude of the field of view and the strength of the illumination diminishes according to the magnifying power of the eye-piece employed. The lower powers are of use in searching for the object to be examined, which may thus be more easily found by a higher power. For the lower power a linear amplification of from 20 to 50 diameters, and for a higher power a linear amplification of from 300 to 500 diameters at most, will give a sufficiently wide range of powers. The powers are increased by a more powerful eye-piece or object-glass, or by both, or by lengthening the tube of the microscope.

1208. In examining vegetable structures, an instrument magnifying 150 to 200 diameters is usually sufficient; but in some instances higher powers are required. Achromatic object-lenses of 1¼, ⅔, and ¼ of an inch, are recommended as the most essential; and two eye-pieces should be provided, one of about 1½ and the other of 2½ inches in length. The instrument should have both a coarse and a fine adjustment; and it is of importance that it should be made to incline at an angle, or to stand horizontally. A moveable stage is also useful, so that the different parts of the object may be viewed without being touched by the fingers, and a spring-holder to fix the objects on the stage. In figure 829 a compound microscope is represented. The stand, or base, consists of a strong tripod, *a*, supporting two upright pillars, *b*, *b*, between the upper parts of which an axis works. This carries the whole of the optical parts of the instrument which can be adjusted to any inclination, horizontal, vertical, or intermediate. The stage, *d*, *e*, is firmly attached to the axis, as is also the double mirror, *f*. The triangular bar, *g*, has a rack on its posterior part, which is worked by a pinion, the milled heads of which are seen at *h*, *h*. The body, *i*, screws firmly into the arm, **j**; the achromatic object-glasses are screwed into the body at *m*; the Huyghenian eye-piece slides into the other end of the body. The mirror is plane on one side, and concave on the other, and is fitted with a universal movement, so as to be inclined in any desired position. The milled heads, *h*, *h*, by being revolved, raise or lower the body, *i*, and constitute the coarse adjustment; the fine adjustment is effected by turning the milled head, *p*. The object to be examined is placed on the stage, *d*, and retained in the required position by the sliding piece, *e*. The quantity of light admitted through the instrument may be modified by the diaphragm, *r*, which consists of a plate of brass with four apertures of different diameters, made to revolve on a central pin or axis fixed to the bottom of the stage. Provision is also made for adding a polarizing apparatus (¶ 1211). In addition to the four holes mentioned as needed to admit the requisite amount of light, the diaphragm is furnished with a fifth hole, into which a Nicol's prism may be screwed, forming the polarizer; the analyzer being screwed into the upper part of an adapter previously to its being attached to the body, *i*. The polarizer is mounted on a double tube, so as to be capable of being revolved by turning a large milled head at the bottom. A condensing lens for illuminating opaque objects may be fitted into the hole at the corner of the stage; it is so arranged that it can be used in any required position or angle. Among the objects often furnished with the microscope is a plate of selenite, which, if laid under many animal and vegetable structures while being examined by polarized light, will cause them to assume beautiful colours. Nachet has invented a binocular microscope by which the objects are seen in relief.



829

1209. **Micrometer.**—In measuring the size of microscopic objects, a *micrometer* (μικρὸς, small, and μέτρον, a measure) is employed. The stage micrometer consists of a piece of glass, ruled with fine lines by means of a diamond point, at some known distance apart, such as the $\frac{1}{100}$th or $\frac{1}{1000}$th of an inch. A mode of ascertaining the magnifying power of the compound microscope is founded on the assumption, that the naked eye sees most clearly and distinctly at the distance of ten inches. If a divided scale be placed on the stage, and distinctly seen magnified through the instrument, let a rule be held at ten inches' distance from the right eye, while the observer uses, at the same time, his left eye in looking at the other scale through the microscope, and let the rule be gently moved so that it is seen to overlap or lie by the side of the magnified picture of the other scale,—a comparison as to how many of its known divisions correspond with a number of those on the magnified scale, will indicate the magnifying power. Upon a similar principle a pair of compasses may be substituted, whose points being placed on the stage are separated till they cover or mark off so many spaces as magnified by the instrument. If they cover 1 magnified space, and correspond to 2, 3, or more known spaces on the rule, then the instrument is said to magnify 2, 3, or more times linear that known space. If $\frac{1}{100}$th of an inch is found to cover 2 inches on the rule, the instrument magnifies 200 times; if 3 inches, 300 times; if 4 inches, 400 times, and so on. In this way is determined the magnifying power of any combination of lenses, and the scale which is magnified is called the object-glass micrometer. The size of objects may be measured by placing them directly on this micrometer; but it is obvious that they cannot under high powers be brought into focus at the same time as the lines of the micrometer. An instrument called the eye-piece micrometer is therefore generally used. It consists of a known scale ruled on glass, and placed in the focus of the upper glass of the eye-piece. The glass is divided by lines varying from $\frac{1}{25}$th to $\frac{1}{100}$th of an inch apart, and is placed either in the focus of the eye-lens or below the field-lens. It is observed with it how many of its divisions correspond with one division magnified by the microscope. Thus, if with an instrument which is known to magnify 250 diameters linear, it is found that 1 space of the magnified micrometer corresponds with 5 of the eye-piece micrometer, the size of the object will be $\frac{1}{5}$th of the known scale. If the scale be $\frac{1}{1000}$th part of an inch, and the object is seen to correspond to 1, or to 4, or to 5 of those spaces, then its size is the $\frac{1}{1000}$th or $\frac{4}{1000}$th, or $\frac{5}{1000}$th part of an inch. In using the eye-piece micrometer, the marked side of the glass is put undermost. Other kinds of micrometers are also employed, such as the cobweb micrometer, where, by the motion of a screw, fine hairs or cobwebs are made to separate from each other. The exact size of objects can only be determined by actual measurement; but at the same time the size may sometimes be conveniently compared with that of any other familiar microscopic object, such as a human blood disc, or the like.

1210. **Microscopic Apparatus.**—In delineating minute structures, it is useful to have the image thrown on paper by means of a *camera-lucida*, or small prism, which can be easily attached to the microscope. In the apparatus sent along with microscopes will be found a *compressorium*, for the purpose of applying pressure to objects whilst they are under examination, troughs for holding such plants as Chara, which are to be seen in water, and various instruments for the dissection and examination both of animal and vegetable structures. In testing the power of the instruments, certain minute objects are used, such as the scales of Podura plumbea or common Springtail, of Lepisma saccharina or sugar-louse, of Hipparchia janira or common meadow butterfly, Pontia brassica or cabbage butterfly, the hair of the larva of Dermestes or bacon-beetle, muscular fibrillæ, and the minute markings of the Diatomaceæ, as Pleurosigma hippocampus.

Certain markings occur in these *test-objects*, which can only be seen properly by good microscopes. In viewing objects under the microscope, they must be placed on slips or slides of glass, which should be of a uniform size, not less than three inches by one; and they should be covered with round or square pieces of very thin glass, $\frac{1}{50}$th to $\frac{1}{100}$th of an inch thick. The slides ought to be made of thin plate-glass, and the covers of very thin crown or plate-glass. In examining recent vegetable structures, it is best to moisten them with water. When the parts are dry, thin sections may be made either by means of slicing instruments, or by a sharp knife. Many dry objects are well seen when immersed in Canada balsam. To preserve objects in a moistened state, the substances used are alcohol, a mixed solution of salt and alum and corrosive sublimate, water containing a small quantity of creasote (5 grains to the ounce), and glycerine. The objects, in such instances, are placed in shallow glass cells, or they are laid on the slides and covered with thin glass, which is cemented by means of japanner's gold size, or black japan varnish. The methods of proceeding are afterwards described.

1211. *Polarization and Polarizing Apparatus.*—When a ray of light is reflected or refracted in certain peculiar conditions, it acquires remarkable properties, and is said to be polarized.* Light is polarized by reflection, simple refraction, double refraction, and by absorption. Double refraction is seen in certain crystals which have the power of separating a ray of light passing through them into portions. By absorption is indicated the property possessed by certain transparent media of absorbing or stopping a part of a ray of light and transmitting the remainder. In the case of common or unpolarized light it is supposed that the vibration of luminous particles takes place in more planes than one—two of these planes being at right angles to one another, and the particles vibrating first in one plane and then in another. Polarized light, on the other hand, is produced by vibrations in one plane.

Difference between Common and Polarized Light.†

A Ray of Common Light,	*A Ray of Polarized Light,*
1. Is capable of *reflection*, at oblique angles of incidence, in every position of the reflector.	1. Is capable of *reflection*, at oblique angles of incidence, *in certain positions only* of the reflector.
2. Penetrates a plate of *tourmaline* (cut parallel to the axis of the crystal) in every position of the plate.	2. Penetrates a plate of *tourmaline* (cut parallel to the axis of the crystal) in certain positions of the plate, but in others is wholly intercepted.
3. Penetrates a *bundle of parallel glass plates*, in every position of the bundle.	3. Penetrates a *bundle of parallel glass plates*, in certain positions of the bundle, but not in others.
4. Suffers *double refraction* by Iceland spar, in every direction, except that of the axis of the crystal.	4. Does not suffer *double refraction* by Iceland spar, in every direction, except that of the axis of the crystal. In certain positions it suffers single refraction only

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* Derived from the supposed analogy to the poles of a magnet.

† Pereira on Polarized Light, p. 48.

1212. A polariscope is used to ascertain whether light has undergone polarization. This consists of two parts, one for polarizing the light, called the polarizer, the other for examining the light, called the analyzer or test. In the compound microscope a prism of Iceland spar (prepared by dividing the oblique rhombic prism into two wedges and then joining the two edges by Canada balsam), is placed under the stage as a polarizer, and a similar prism is placed over the eye-piece as a test. The Canada balsam separates the two images of the doubly refracting spar to such an extent that one only is seen through the prism. Two thin plates of tourmaline may be used instead, and in that case the light is polarized by absorption. When light reflected from the mirror through the polarizer is examined by the analyzer it is found that, upon revolving either the one or the other, the light is twice completely stopped on each revolution, and the field of view darkened. To exhibit the phenomena of polarized light, interpose between the polarizer and analyzer a thin plate of some doubly refracting substance, which is called the depolarizer. This depolarizer divides the ray into two, or produces two systems of waves polarized in planes at right angles to each other. One of these systems traverses the depolarizer more slowly than the other, and thus the two intersect each other, or *interfere*, and in this case colour is usually produced.

1213. A writer in the "North British Review," for 1856, makes the following observations on the polarizing microscope:—Certain structures in minerals and plants, and on the tissues and various parts of animals, are wholly invisible in the microscope. In the cornea and crystalline lenses of animals in composite minerals, and in simple minerals, such as amethyst, analcime, and apophyllite, in a great variety of crystals, to which the name of circular has been given, and in plants, there are beautiful organisms arising from differences in density, to which the human eye, even if assisted by the best microscopes, is absolutely blind, when viewed by common light. This light as it comes from the sun, and from artificial flame, consists of, or may be divided into, two kinds of light, as electricity may be divided into vitreous and resinous, or magnetism into north polar and south polar. Thus divided, common light is said to be polarized, and the two portions exhibit different properties when reflected from, or transmitted through bodies. If we suppose a cylindrical beam of common light to be composed of different parts, like a number of shillings arranged in a cylindrical row with the queen's heads lying in all directions—then, if one half of the shillings, separated from the other half, have all the queen's heads standing upright, and if the other half have all the queen's heads lying horizontally, we shall have an idea of polarized light. Now, the separation of common from polarized light may be effected by making light pass through several plates of glass, at an angle of about 55°; all the reflected light will be polarized like the cylinder of shillings with the queen's heads upright, and the transmitted light (when the plates are sufficiently numerous) like the cylinder with the heads lying horizontally. Light similarly reflected from a single polished surface of transparent or black bodies, not metallic, will also be polarized. Common light may be divided into two polarized pencils, by passing through certain crystals, such as Iceland spar or quartz. Each pencil is polarized oppositely, and when a rhomb of Iceland spar is cut into two parts, and these parts are conbined so that one of the pencils is hindered from reaching the eye, it constitutes a Nicol's prism, now used in the polarizing microscope. In certain crystals, such as tourmaline and herapathite (the sulphate of iodo-quinine), one of the pencils is absorbed, and plates of these substances, therefore, are used in microscopes as polarizers. When polarized light has passed through any transparent body, a change is made visible by looking through another polarizer placed transversely to the first polarizer, which is called the analyzer. The structure of the microscopic object is thus displayed in different colours, or in different shades of white light, the colour or the degree of light depending on the thickness of the different parts of the object. The forms thus disclosed to the eye are at once splendid and beautiful.

1214. The polarizing microscope, simple and compound, was first constructed and used by Sir David Brewster in 1815. In the Simple Polarizing Microscope, a single lens or a doublet with a piece of tourmaline the size of the pupil, as the analyzer, is placed between it and the eye; the object is then examined by polarized light produced by reflection or otherwise. The magnifier and analyzer may be united in a lens of tourmaline. In the Compound Polarizing Microscope, the analyzing Nicol's prism is placed immediately between the object glass, and another Nicol's prism, or a small rhomb of spar, presenting one of its pencils to the object, is placed beneath the object. Along with the polarizing apparatus, there is generally sent a plate of selenite (which is a film of sulphate of lime or gypsum) of such a thickness as to polarize a blue of the second order. This plate is used to show weak polarized tints, as well as to show off the colours of polarizing structures by displaying them on a blue ground. When thus exhibited, all the negative tints (as they may be called) are diminished, and all the positive ones are increased; and the effect of the plate is to mark the true character of the phenomenon.

1215. In proceeding to use the microscope, it is necessary to have a variety of tools and apparatus to aid in preparing objects for investigation. These may be arranged beside the observer in such a way that they shall be always within his reach.* A small tray or box, with divisions, containing a pair of needles in handles (such as are used for crotchet needles), a sharp knife or razor, a section-knife (such as that invented by Valentin, and which bears his name), scissors, and a pair of sharp or fine needle-pointed forceps, about three inches long, are among the most essential instruments required. Glass slides may be arranged also upon the same tray for common use, and the thin glasses for covers should be kept in a small box by themselves. In manipulating the object to be examined, certain re-agents are required. These are :—1. Distilled water; 2. Alcohol in the strong state, and also diluted in the proportion of about 1 part to 10 of distilled water. It is the best preserving agent; it removes colour and also air. 3. Ether which dissolves resins, fats, and oils. 4. A solution of liquor potassæ diluted to about 1 to 20. It *swells* up, and sometimes separates membranes of cells and tubes when they exist in condensed layers. 5. A solution of iodine in iodide of potassium diluted to the following strength,—namely, 1 grain of iodine to 3 grains of iodide of potassium, and an ounce of distilled water.

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* The following details are partly condensed from Schacht's treatise on the microscope, and from the works of Hannover, Quekett, Jabez Hogg, and Beale.

6. Chromic acid diluted in the proportion of about 1 to 30 or 40 of distilled water. The last two re-agents chiefly act by colouring the cell walls or the contents of the cells. 7. Sulphuric acid. 8. Oil, such as the finest of that obtained from coal, and known as mineral oil, is to be recommended for examining and preserving objects in. It does not become rancid, nor has it any affinity for oxygen. For the examination of pollen and spores there is nothing better. 9. One part of dry muriate of lime and 3 of water makes also an excellent solution for preserving objects which do not contain starch. 10. Glycerine is the best preserving agent for cells containing starch. 11. Canada balsam; and 12. Turpentine, are most useful re-agents and preservative materials for many dry preparations. 13. A strong solution of carbonate of soda. 14. A solution of hydrochloric acid may also be found useful in removing deposits of carbonate of lime. 15. A solution of acetic acid. 16. A solution of carbonate of potass. These sixteen substances should be arranged in stoppered glass bottles, fitting into a stand or box, so as to be of easy access, and little brushes, pipettes, and glass rods, should be arranged beside these bottles, in order to apply the fluid to the object. Lastly, the student should provide himself with a small note-book of good drawing-paper, on which he ought constantly to practise the delineation of the forms or outlines of the objects seen, and he should endeavour to colour them also when required.

1216. Numerous other requisites and appliances will suggest themselves during the course of investigations, and especially such as will secure cleanliness of the object, and of everything used in the research. 1. One who has any regard for his instrument will never suffer it or its lenses to be handled by those unaccustomed to their use. 2. The microscope, when not in use, must be kept under cover, generally under a glass shade. It should never be exposed in a chemical laboratory. 3. Its lenses must be cleansed when necessary by a cloth which is used *only* for that purpose, or by dry elder pith. The cloth best adapted for this purpose is old and frequently washed linen. 4. A separate cloth of a coarser kind is to be used for drying and wiping the slides and covers. 5. Covers of a middle size, from concave disks, such as watch-glasses, up to the size of a wine-glass without the stem, or other bell-shaped jars, are also required to protect the objects, if it is necessary to leave them for any length of time.

1217. The microscope is used to the best advantage in a room which receives its light from the north, or west, or both. The light which is reflected from a white and motionless cloud opposite to the sun, is the best that can be obtained. If gas-light is to be used, it ought to be corrected or modified by passing it through blue glass shades before reaching the mirror; but for exact observation, daylight is always to be preferred. In conducting microscopic observations, great steadiness of the instrument is required, which should accordingly be set upon a very firm and sufficiently large table, so that all the apparatus hitherto mentioned shall be within reach of the observer. It is proper also to begin the examination of objects with the lower magnifying powers, and to pass gradually from them to the use of the higher powers. By such means a far larger portion of the object is seen, and a more correct idea is obtained of the relations of the parts when considered as a whole. Object-glasses, varying from 30 to

50 diameters, are the best to begin with. The eye-glass of lowest power, that is, the longest one of the series, is also the one which ought generally to be used in the first instance, and as long as the power can be increased by object-glasses of greater magnifying power, any more powerful eye-piece should not be used, because by the use of such eye-pieces the image is rendered more obscure, while less light is obtained for its display.

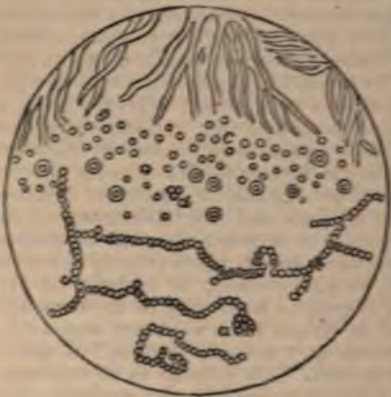
1218.—**Sources of Errors of Observation.**—Extraneous or accidental objects may be present, and may be derived from various sources. Thus, water too long used may bring before the eye both plants and animals of the lowest forms, which otherwise would not have been present. Fresh water is absolutely necessary, and it may be even recently distilled. Particles of dust, or fibres from the cloths used in cleaning the glasses, may also add to the confusion. These consist, generally, of fibres of paper, linen, woollen, cotton, or silk fabrics, or minute hairs from the brushes used in manipulation. Air-bubbles are almost invariably a source of confusion to the microscopic observer in his first attempts; but once seen and studied, they no longer distract the attention, and the microscopist soon gets into the habit of disregarding their presence. They generally appear in the form of circles of larger or smaller diameter, with a dark black-looking rim, seen by transmitted light; while with incident or reflected light, their rim appears of a white colour. Pressure under a glass cover causes them sometimes to assume very irregular shapes, but possessing the same properties in their margin or outline in their behaviour with the light. It is also necessary to become familiar with the appearances of the lowest forms of animal and vegetable life, such, for instance, as the common forms of infusoria, the yeast, and such like plants; and the different forms of mould. It must not be forgotten also, that the various menstrua used in manipulation contain elements which properly belong to them, and which must therefore be distinguished; for example, the epithelium of the saliva, the blood corpuscles which may be in serum, and crystals which may be deposited in various fluids which are used as reagents. A peculiar motion, known as "molecular motion," is also a phenomenon which must be recognized. It is peculiar to all very small particles or molecules, when they float in a very thin fluid medium. It is best seen in the fine granules of milk when mixed with water, in the milky juices of the plants, and may be observed very distinctly in solutions of India-rubber, or caoutchouc, when dissolved in ammonia. A magnifying power of 400 or 500 diameters is the best for this observation. Another class of deceptions originates in the eye itself. These are the "muscæ volitantes," the nature of which is described as follows by Dr. W. Mackenzie in his Treatise on the Eye.

"The vision of objects on the surface or in the interior of the eye has attracted attention, chiefly in relation to a symptom, to which the name of *muscæ volitantes* has been given. Any spectrum, or visual appearance, which is apt to impose on the mind, and lead one to think that flies are moving before the eye, is called a *musca volitans* (fig. 830).

"The condition comprehends those sensations which arise from, 1. The layer of mucus and tears on the surface of the cornea; 2. Corpuscles between the external surface of the cornea and the focal centre of the eye; 3. Corpuscles between the focal centre of the eye and the sensitive layer of the retina.

"In hanging the head over the microscope, especially if one is affected with catarrh at the time, the globules, by gravitating to the centre of the cornea, not unfrequently appear to the observer so as so impede his view of the object, till by the act of nictitation he clears them away. In telescopic observations, also, the muco-lacrymal spectrum is apt to prove a source of annoyance. Thus, in looking at the sun through a tinted glass, the observer may be unable to distinguish the spots on that body, being perplexed by what seems the reflection of some part of his own eye interposed between it and the sun. This is caused by the layer of mucus and tears on the surface of the cornea.

"If one looks at the flame of a candle two or three feet distant, or at the sky, through a hole made in a blackened card with the point of a fine needle, or through a convergent lens of short focus, such as the eye-glass of a compound microscope, on steadily regarding the luminous field presented to view, four sets of spectra will be seen (fig. 830), independent of the muco-lacrymal spectrum. The most remarkable appears nearest to the eye, and consists of twisted strings of minute pearly globules, hung across the field of view (fig. 830 *a*). The second in point of remarkableness, and the farthest of the four from the eye, consists of watery-like threads, destitute of any globular appearance, and depending chiefly from the upper part of the field (fig. 830 *b*). I call the former the *pearly spectrum*, and the latter the *watery spectrum*. In two distinct planes, between those occupied by these two spectra, float two sets of globules, not aggregated into threads, but insulated. These constitute what I call the *insulo-globular spectra*. The individual globules of the set farther from the eye, being hazy and ill-defined, may be compared in appearance to small grains of sago (fig. 830 *c*). The globules of the set nearer to the eye are clear in the centre, exteriorly to which they present a sharp black ring, and still more exteriorly a lucid circumference (fig. 830 *d*). These four sets of spectra never mingle with one another, so as to change the order in which they stand before the eye; but the pearly spectrum always appears the nearest; then the sharply defined insulo-globular; then the obscurely defined globules; and farthest away the watery threads.



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"Almost every eye, even the most healthy, and which has never attracted the possessor's attention by muscæ volitantes, exhibits the pearly spectrum, on being directed towards a luminous field, through a fine pinhole, the eye-glass of a compound microscope, or a convex or concave lens of short focus. I have given it the same name of the *pearly spectrum*, from its resemblance to a string of pearls. Prevost had already called it *apparence perlée*, or simply *perles*.

"The lines of the pearly spectrum are hung across the field of vision as often transversely as vertically. On first directing the eye towards the luminous field, in one or other of the methods just mentioned, perhaps only a very few small pearly globules are perceived; but after steadily regarding it for a short time, numerous strings of them are discovered, generally twisted in different forms, and presenting a variety of knots, loops, and agglomerations. Sometimes they are so numerous as to form an extensive shower or cloud. The pearly threads are of different lengths; some of them very short, others stretching across the whole field. Not unfrequently some of them end abruptly in a sort of bulb. The globules or pearls forming the threads or rosaries, seemed joined together merely by apposition, without being contained in any tube. Sometimes, however, the globules are rather indistinct, and then the threads approach to a tubular appearance. The globules are always in single rows. They appear destitute of any nucleus. They are not all of one diameter, but are all smaller than the globules of the insulo-globular spectra. I have not satisfied myself that all the pearly threads occupy the same plane, although it is very evident that they are behind the insulo-globular spectra.

"That portion of the pearly spectrum which appears in the centre of the field of view has but little real motion, less perhaps than the watery spectrum which is seen beyond it. Both partake, of course, in the motion of the eyeball; and this gives to both a wide apparent motion. But if the field be examined towards its circumference, or if the eye be suddenly rotated upwards, other pearly spectra appear, which it is difficult or impossible for the observer to bring directly before him; and which, when he succeeds in some measure in doing so, quickly subside again out of view, partly by a real motion of their own, partly by a wide apparent motion, owing to their obliquity in respect to the axis of vision. It is these last spectra, chiefly, which produce the pearly muscæ volitantes."

There are also various optical phenomena caused by refraction, and which are necessary to be attended to. They depend, for the most part, upon a bad adjustment of the focus, or illumination of the object. The appearances are also most frequently associated with an increase of the magnifying power, and especially with the use of powerful eye-glasses. Large grains of potato-starch, pollen-grains, the thickened substance of wood-cells, and the cells of cartilage, are among the most common objects which exhibit such optical phenomena, which consist in a feeble and generally yellowish colouring of the edges of the objects when seen with particular foci.

1219. **Focal Adjustment of the Microscope.**—The regulation of this adjustment is based on the fact, that the microscope can only afford a view of one surface of an object at any given time, so that nothing is distinctly seen which lies above or below such a focal plane at that time; and the more flat the field of vision, the clearer and better will be the view of objects in that plane if the adjustment is correct. The more perfect the object-glass, and the greater the angle of aperture,* the more exact is this focal plane, and the more sensitive is the instrument to any small alteration of focus. The focal adjustment is made and varied by what is called a fine adjustment screw, and which is sometimes graduated; and the accurate adjustment of the object is judged of by the sharpness of the delineation of the image, as well as by the fineness and clearness of the outline. An experienced microscopic observer always uses the instrument with his finger and thumb grasping the fine adjustment screw, and would not be content with his observation, although it was limited to a mere peep of the object, unless he had made the fine focal adjustment for himself.

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* The angle of aperture is that made by two lines from opposite ends of the aperture of the object-glass with the point of focus of the lens. A glass with a large angle of aperture shows

1220. **Preparation and Selection of Objects for Examination.**—Opaque objects require merely to be made smooth or level on one side, and to be fixed on the other. If the object is to be viewed by transmitted light, a section or slice sufficiently thin must be procured; a common sharp knife, a razor, or Valentin's section knife are the instruments to use. They must be moistened with water, and sometimes it is advisable to make the section under water. If the object is very delicate it may be laid between two pieces of cork, and the whole cut through. If the object is hard, such as a fossil plant, it must be ground down with a file, a grindstone, or a lap, and then polished on one surface. This surface is to be fixed to a glass slide by Canada balsam, and the opposite surface rubbed down and polished in a similar manner, till it is sufficiently thin to be viewed by transmitted light, and it must be of uniform thinness. Sections should be made in various directions, so that a correct knowledge may be obtained of the relation of the component parts. Maceration in water, and tearing the parts asunder with fine needles, are the best methods for obtaining the ultimate tissues of plants. Thin glass plates to cover the object under the microscope must be invariably used. They prevent evaporation, and preserve the moisture about the object; they prevent the object-glass from being covered with vapour, and so rendered obscure, and, lastly, they produce a slight pressure, by which the elementary parts of the substance may become separated from each other, so as to lie on one plane. The thin covers are not absolutely necessary where very low powers are used. In placing the object on the stage care must be taken not to bring it in contact with the object-glass of the instrument. It is also to be remembered that, in a compound microscope, the image is inverted, and that, consequently, the object is moved in a direction contrary to that of the image.

The following list of tissues to be examined by the student of Vegetable Histology, is taken from the preparations used in the microscopical demonstrations given to the pupils of the Botanical Class in the University of Edinburgh.

Cellular Tissue.—Sea-weeds, Confervæ, Moulds and other Fungi; Lichens, Liverworts, pith of Elder, and of the Rice-paper plants (Aralia and Æschynomene), outer bark as of the Cork and of Elephantipes, succulent roots, stems, and fruits, as Orange and Lemon.

Nucleated Cells.—Onion, Yeast plant, Vinegar plant, ripe fruit of Strawberry, Smut, ovules or very young seeds.

Independent Cells.—Red-snow plant (Protococcus nivalis).

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objects clearly. The angle varies usually from 50° to 100°. Many glasses, however, are made with a much higher angle. Ross makes glasses of 170° of angular aperture. These are useful for observing minute organisms, such as Diatoms.

Thickened Cells.—Shell of Coco-nut, stone of Peach, Cherry and Nut, seed of Ivory-Palm and Date, gritty matter of Pear, scales of Cone.

Pitted or Porous Cells.—Elder, stem of Common Balsam, outer covering of seeds of Gourd and Almond.

Spiral Cells.—Leaves, stems, and aerial roots of many Orchids, as Oncidium and Pleurothallis ruscifolia, leaf of Sphagnum, episperm of seeds of Collomia, Acanthodium, Calempelis scaber, Lophospermum, and Cobæa, pericarp of Salvia.

Stellate Cells. — Juncus conglomeratus and other rushes, petiole of Banana and Plantain, and of Sparganium ramosum, stems of many aquatic plants.

Ciliated Cells.—Spores of Vaucheria and some Fuci.

Filamentous Cells.—Fungi.

Pollen Cells.—Anthers of Tulip, Lily, Passion-flower, Acacia (cells united in fours), Zamia, Cycas, Tropæolum, Gloxinia, Colocasia, pollinia of Asclepias and Orchids.

Pollen Tubes.—Œnothera, Antirrhinum, Hibiscus, Linaria, Gesnera, Crocus.

Embryonic Cells.—Orchis, Listera, Hippuris, Euphrasia, Draba.

Spores or Reproductive Cells.—In Cryptogamous plants, Ferns, Mosses, Lichens, Algæ, and Fungi, Zygnema when conjugating.

Cells with Siliceous Covering.—Diatoms, cuticle of grasses, Equisetum.

Cells encrusted with Carbonate of Lime.—Chara.

Epidermal Cells.—Leaves, Hyacinth, petals of Pelargonium, Apple, and Digitalis.

Hairs.—On leaves, and in pappus of Compositæ, Cotton (twisted), articulated hairs on leaves of Goldfussia and Alstrœmeria ovata, pappus of Trichinium, moniliform hairs on stamens of Tradescantia, stellate hairs of Deutzia and Aralia papyrifera, peltate hairs of Malpighia urens, glandular hairs of Nettle, Loaza, Chinese Primrose, and Dionæa.

Glandular Cells. — Sweet-Briar, Passiflora lunata, Ice-plant, Lilac, Cinchona, Rhamnus, Rottlera, Aloysia, Mentha.

Scaly Cells.—Ferns, as Polypodium sepultum, and Niphobolus, and Ceterach, Hippophäe, Begonias, Olive.

Starch in Cells.—Potato, Arrow-root, cereal grains, Bean and Pea.

Raphides.—Hyacinth, Rhubarb, Arum, Onion, Squill, Balsam, Cactus, Lemna trisulca, Ficus, Aloe, Banana, petal of Ornithogalum.

Stomata.—Hyacinth, Begonia, Oleander, Lilium, Equisetum, Box, Gasteria, Marchantia, Crinum, Yucca, Bilbergia.

Antheridia and Archegonia.—Prothallus of Ferns, Mosses, Fucus, Marchantia, spermatozoids in Ferns and Chara.

Conjugating Cells. — Zygnema nitidum, Tyndaridea, Cylindrocystis, Desmidieæ.

Vascular Tissue.—Young stems of Herbaceous plants.

Spiral Vessels.—Canna bicolor, Pitcher plant (Nepenthes), Banana and Plantain, Cactus, Hyacinth, Asparagus, Balsam, Strelitzia, branching spirals in Mistleto, Long-leek, and Anagallis.

Annular Vessels.—Opuntia vulgaris, Leek, Equisetum Telmateia.

Dotted Vessels.—Sugar-Cane, Nepenthes, Willow, Clematis Vitalba.

Reticulated Vessels.—Garden Balsam.

Scalariform Vessels.—Common in Ferns, Osmunda, Asplenium, Cheilanthes, Pteris.

Laticiferous Vessels.—Ficus elastica, Euphorbia, Tragopogon, Chelidonium, Lactuca, Isonandra gutta, Dandelion.

Woody tissue.—Stems of trees, inner bark especially of plants yielding useful fibres, as Lace Bark tree, Cuba Bast, root of Elder, Cabbage.

Punctated Woody Tissue.—Stems of Coniferæ, Pinus, Abies, Araucaria, fossil stems, Cycas, Illicium, and with spirals in Yew.

1221. **Preservation of Microscope Objects.**—The following apparatus is required, viz., glass-slides ground at the edges, and of the requisite standard size, with circular glass covers. Preserving agents, cement, and a moveable circular disk for mounting and making cells. Among the preserving media for vegetable substances, are—A solution of chloride of calcium, glycerine, copal varnish, mineral oil, Canada balsam. Among the cements used for vegetable objects, are the following :—Brunswick black, japanner's gold size, black japan, sealing-wax varnish, Robinson's liquid glue, gum mastic and caoutchouc dissolved in chloroform. Objects are put up (*i. e.*, preserved) either as dry or as wet objects. For dry objects, the oils and the Canada balsam are the preservative materials, and they are not suited for wet objects. Before mounting objects in Canada balsam they should be perfectly clean and free from moisture. They may also be soaked in turpentine, especially opaque objects, as it renders them more transparent. In mounting, the balsam should be heated to expel the air, till a fine delicate film is apparent on its surface. The solution of chloride of calcium is adapted for the preservation of wood and leaves, and for most kinds of isolated tissue. The colouring matter in the cells, however, is always more or less altered by it, while grains of starch, if present, swell up and can scarcely be recognized. The strength of the solution is one part of lime to three of water. Glycerine is used in equal parts mixed with camphor water, which prevents the tendency to mildew. The chlorophyll and the grains of starch remain unchanged, and the laminæ of the starch appear more beautiful after a few hours' immersion in the glycerine solution. Canada balsam and copal varnish are used for the preservation of dry and fossil woods. Thin sections should be made, and the hard woods which contain gum, resin, and such like matters, should be soaked in essential oil, alcohol, or ether, before mounting. If the entire structure of any exogenous wood is required to be examined, the sections must be made in at least three different directions, which may be termed the transverse, the longitudinal, and the oblique, or, as they are sometimes called, the horizontal, the vertical, and the tangential, each of which exhibits different appearances. The vertical section should show the number and size of the medullary rays, that is, the small portions of pith which proceed horizontally from the centre, enclosed between the layers of woody fibres, and which are known to the cabinet-maker as the silver grain of the wood. In coniferous trees, as the pine, this section shows also the beautiful punctations on the walls of the fibres. The tangential-vertical section is a slice across the medullary rays, and exhibits the form and arrangement of the cellular tissue in them. These vertical sections show the form, size, and connections of the woody fibres, the spiral, reticulated, and dotted vessels. In endogenous trees horizontal and vertical sections only are required.

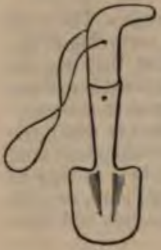
Peat wood requires to be digested in a strong solution of carbonate of soda, and fossil woods which have been converted into carbonate of lime should be digested in hydrochloric acid.

1222. **To make Cells, and to fix the thin Glass Covers.**—The cells are made either round or square by thin layers of cement, according to the depth required. Perhaps the round ones are neater, but they require circular pieces of glass for covers, and by the aid of the moveable circular disc, the roundness of the mounting can be made with perfect accuracy. The cover is laid gently down, so as to float on the solution in which the object lies, and by pressing carefully on the cover, the superabundant fluid is made to pass out by the edges, and may be taken up by a sponge or blotting paper. A thin layer of Brunswick black, or liquid glue, or gold size, may be placed round the edge, which will gradually harden and completely seal up the preparation.

II.—On Collecting and Examining Plants, and on the Formation of an Herbarium.

1223.—**Instruments and Apparatus.**—In examining the characters of plants with a view to classification, the chief instruments required are a lancet-pointed knife, a small pair of forceps and a lens. In more minute examinations, the simple or compound microscope must be called into requisition. In selecting specimens, care should be taken to have the plants in a perfect state, or with all the characteristic parts present. The entire plant should be taken when practicable; when that is not the case, then those parts should be taken on which the generic and specific characters are founded. The roots should always be carefully washed at the time the plants are gathered. In most cases, particularly in specimens of Umbelliferæ, Leguminosæ, Compositæ, Rosæ, &c., it is of importance that both flowers and fruit should be preserved. In the case of Willows, the young shoot, with its fully developed leaves, as well as the male and female flowers, are requisite. In Rubi, specimens of the young shoots must be taken. When bulbs or tubers exist, they should be preserved, either in an entire or split condition; and when there is much mucilaginous matter in them, they may be enveloped in small pieces of paper, so as to prevent them from adhering to the drying paper. In the case of Ferns, two fronds are necessary to make a perfect specimen, showing both surfaces, along with a portion of the rhizome. Entire specimens of Gramineæ and Cyperaceæ should be collected; these, when long, may be bent into one or more folds, corresponding to the size of the paper on which they are to be fastened, the folds being temporarily retained by small slips of paper having slits in the centre. No bad specimens ought to be preserved.

1224. In taking up the roots of plants, a small *Digger* or trowel is used, 7 or 8 inches long (fig. 831); the spud 2½ inches long, 2½ inches wide at the top, narrowing gradually to 2 inches at the bottom, the lower angles slightly rounded. This can be put into a leather sheath, and fastened by a strap round the waist, the spade itself being attached to the strap by a long string. A japanned tin box or *Vasculum* is required for the reception of specimens. This should be ot sufficient length to receive a plant of the full size of the herbarium paper; it ought to be convex on both sides (fig. 832); and its capacity may vary according to the wish of the collector. In long excursions where productive localities are visited, it will be found that a vasculum 20 inches long, by 8 or 9 inches wide, and 5 deep, is not too large; and when it is made of thin tin, it is by no means heavy. At one end a good sized thickish handle should be placed, and it is necessary to have wires fixed at each end so as to receive a strap for fastening the vasculum on the shoulders. The lid of the vasculum should be large, and is best secured by a wire which slips into a tin sheath, and so constructed as not to be liable to slip out when the box is held by the handle. For mosses and some Alpine species of plants, a small box may also be carried in the pocket. Many plants will not bear transport; their flowers fall off easily, and they are so delicate that their foliage becomes shrivelled. In such instances it is best to put them at once into paper. This is managed by having a small *Field-book* (fig. 833), which may be put into the pocket or suspended round the neck, secured by straps so as to give pressure, and with an oil-cloth covering which may be used in wet weather. This field-book may be made with two thin mahogany boards on the outside.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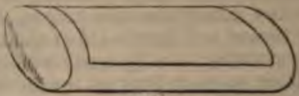
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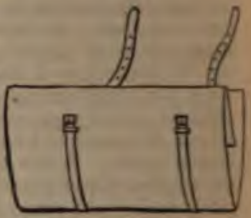
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1225. The *Paper for drying* should be moderately absorbent, 18 inches long by 11 broad, and arranged in parcels containing not less than four sheets. The paper which is used extensively in Scotland, is made by Cowan and Co., Princes Street, Edinburgh. In many respects, the Edinburgh botanists prefer it to Bentall's. It is of considerable thickness, absorbs moisture rapidly, but does not become too moist. and dries easily. A very thin kind of paper, called crown tea-paper, is used for holding very delicate plants, which cannot be easily transferred from one paper to another during drying. After being carefully laid out in the folds of this paper, they are placed between the sheets of drying paper, and when the paper is changed they are transferred at once in their thin cover without being disturbed.

1226. In order that pressure may be given, *Boards* are requisite. These should be exactly the size of the drying paper. Some of them are used for outside boards, and these ought to be thicker and stronger than the rest; others are inside boards, about $\frac{3}{8}$ of an inch thick. For every two reams of drying paper, not less than ten boards should be procured; two of which are for the outside, and eight for the inside. Sheets of stout pasteboard are also useful for packing up the plants as they become dry. The pressure is best applied on a botanical excursion, by means of a rope put twice round the boards and paper, and tightened by a rack-pin. This is much better than straps, which are apt to give way, and are with difficulty replaced during an excursion. In other circumstances, pressure is best applied by means of heavy weights. The pressure ought not to be less than 100 lbs. This is preferable to a screw-press, in which the pressure is not kept up while the plants are losing their moisture. Boards may be replaced by frames of hard wood, furnished with cross-bars. They are lighter, and have the advantage of leaving a portion of the surface of the packet in contact with the air, and consequently of hastening dessication, at the same time they are less solid than the boards. Sheets of tin may be employed to separate the different layers of plants in process of drying, so as to hinder the humidity of one from reaching the other, or the inequalities of the larger from injuring the smaller and more delicate. In the case of plants with strong stems, they must either be split, or a sand-bag, of the same size as the boards, used, so as to equalize the pressure.

1227.—**Process of Drying.**—The plants when collected are to be placed on the drying paper. In doing this, a parcel of not less than four sheets is put on one of the outside boards; then the specimens are laid out carefully, preserving as far as possible their natural habits, and laying out the leaves and other parts. Another parcel of drying paper is then placed above these, and the same process is repeated with other specimens until twelve such parcels have been placed together. Then one of the inner boards is laid down, and other layers of paper and specimens are applied, until the whole parcel is of sufficient size to be subjected to pressure. After twelve hours' pressure, in most instances, the paper is changed, the moist paper being hung up to dry; and in transferring the specimens from the wet to the dry paper, a large pair of surgeon's forceps is used. The interval elapsing between the changing of the paper may be increased or diminished according to the nature of the plants, and the state of the weather. In the course of eight or ten days, ordinary specimens will be so dry as to require only very slight pressure, with a moderate circulation of air. Some very dry plants, as grasses, may require only one changing. Succulent plants, such as Sedum and Sempervivum, continue to grow, however much submitted to pressure and the ordinary methods of dessication already indicated. In order to dry these plants completely and rapidly, it is necessary to kill them, by immersion in boiling water for five or ten minutes. The plants thus dealt with are then placed upon a cloth and left to drain for some time, after which they must be carefully placed between the folds of the drying paper, not forgetting to lay out properly any of the parts which the water may have disarranged. Orchideous plants are sometimes put into warm paper, and changed frequently, with the view, if possible, of preserving their colours by the rapidity of drying. Scarification has sometimes been adopted with the view of allowing the juice to flow out rapidly. Motley recommends that Orchids should be put into weak spirit for one or two nights, and then dried. At the time the specimens are laid out on the drying paper, a label should be inserted with the date of collecting, the name of the station, its elevation above the sea (if it can be ascertained), and any remarks as to soil or geological structure that may be known. With the view of transporting dried plants securely in wet weather, it is useful to have a supply of oil cloth to cover them.

1228. Mosses may be collected in excursions in tufts, and dried by moderate pressure at first. They can afterwards be separated, moistened, and dried with greater pressure. They ought to be gathered in fructification. Lichens sometimes require to be taken with the rocks or stones to which they are attached, and they may be merely wrapped up in paper. Sea-weeds must be washed with fresh water before being laid out. The more delicate kinds are floated out on pieces of stiff paper, and afterwards dried by moderate pressure. In preserving fungi, such as Agarics, etc., a thin slice is taken from the centre, extending from the top of the pileus to the base of the stipe. This is dried separately to show the gills or pores, etc. The inner cellular portion of the pileus and stipe is then removed, and these parts are dried so as to give the form. Travellers visiting foreign countries (although not botanists) will find it an easy matter to preserve Mosses, Lichens, and Sea-weeds in a state fit for after-examination. In the case of Sea-weeds, it is necessary to avoid such specimens as are in a state of decay. Those which are taken should be spread out in the shade to dry, without washing them with fresh water, and when quite dry, packed loosely in a box. Many species are found thrown upon the beach, and the pools in the rocks at low water are often filled with excellent specimens. The stems of the larger Algæ are often covered with parasitic species, which should be dried without separation.

1229. When the specimens (whether Phanerogamous or Cryptogamous) are fully dried, they are then selected for the herbarium, and are fastened upon fine stiff paper, fit for writing upon, 17 inches by 10½.* In large herbaria, which are constantly consulted, the best way of securing the specimens is by means of fine thin glue; the plants, after the glue is put on them, being made to adhere to the paper, by pressure between folds of drying paper. Some use gummed paper, others use thread or narrow ribbon, by means of which the specimens are sewed to the paper. Plants of certain families, as Compositæ, are more particularly exposed to the ravages of insects. Hence, all plants after being dried, should be brushed over with an alcoholic solution of corrosive sublimate.† This treatment has the inconvenience of discolouring them more or less completely, and making them assume a light brown tint; but there can be no hesitation between the alteration of their colour and the complete destruction with which they are menaced, if not submitted to the above manipulation; some recommend cyanide of potassium to destroy insects. In herbarium-presses camphor is employed to prevent the attack of insects. The specimens must be kept dry, and frequently examined, and when insects are present, they must be retouched with the solution already indicated.

1230. **Specimens in a moist state.**—In preserving fresh specimens of fruits, and the other parts of plants, the best mode is to put them into a saturated solution of salt and water. They can thus be sent home from foreign countries in jars or barrels. In making a museum of such specimens, they are put into glass jars, the sizes of which should be regular—4, 8, 12, and 16 inches high, with a diameter varying according to the size of the specimen. The glasses may be filled with the following solution, which is nearly the same as that used by Goadby, and which seems to answer well in most instances:—

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* The paper used in Edinburgh is made by Cowan and Co. under the name of "M. R. Laid Medium, flat 4to," and costs two guineas a ream when cut.

† The solution commonly used consists of 30 grains of camphor, and 20 grains of corrosive sublimate to an ounce of alcohol.

Bay salt	4 ounces.
Burnt alum	2 ounces.
Corrosive sublimate	20 grains.
Boiling water	2 quarts.

Dissolve and filter the solution. Spirit is often used, but it usually makes all colours alike brown. It is useful for delicate specimens which are required for dissection. Diluted acetic acid is also very generally employed. The mouth of the glass jars may be conveniently covered with India rubber, or in the case of glasses of small diameter, with a watch glass secured by sealing wax, or by circular glass covers cemented by a lute composed of resin 1 part, wax 2 parts, and vermilion 1 part.

1231. **Seeds,** when sent from abroad, should be collected perfectly ripe and dry, and if possible kept in their entire seed-vessels. Small seeds may be folded in cartridge paper, and should be kept in a cool and airy place during transport. Large seeds and oily seeds, which lose their germinating power speedily, are best transported in earth. A box about 10 inches square, with the sides ¾ of an inch thick, answers well. In this may be put alternate layers of earth and seeds, the whole being pressed firmly together. Living plants are best transported in Wardian cases (¶ 297), and seeds or fruits may also be scattered in the earth of the cases. Bulbs and rhizomes not in a state of vegetation, cuttings of succulent plants, as aloes and cactuses, and the pseudo-bulbs of Orchideous plants, may be put into a box or barrel with dry moss, sand, peat, or sawdust.

1232. *Hints as to the preparations to be made for alpine travelling, particularly in Switzerland, partly taken from Wills' "Wanderings on the High Alps."*

A botanical trip for six weeks in Switzerland, including the expense of going and coming, need not cost more than twelve shillings a day. In a pedestrian tour the traveller must be as lightly equipped as possible; at the same time he must so provide as to have a change of dress in case of wet weather. The Botanist must send his heavy portmanteau and his drying paper, with boards, rope, and rack-pin, to different points by railway or post. During his alpine rambles, he will find that he can only carry his box, spade, field-book, alpenstock, and light waterproof. His knapsack, *while he is botanizing*, must be carried by a porter. He should, however, be prepared on an emergency to carry all his alpine baggage with him, more especially when passing from one station to another by some beaten track, where few plants are to be expected. A large party will find it convenient and economical to hire a horse for the conveyance of their knapsacks.

The articles required are as follows:—

A light waterproof knapsack, which will bear rough usage, about 14 inches long, 10 inches broad, and 3½ inches deep, with two light straps at the top to hold a very light waterproof, and a stout leather handle by which to carry it, if necessary. The straps for the shoulders should be broad. One of the shoulder straps should end in a ring, and a hook should be fastened on the lower edge of the knapsack to receive it. By this contrivance the knapsack is easily taken off. The whole apparatus ought not to weigh above 2 lbs.

Good shoes, large, so as to allow for the swelling of the feet, the soles from $\frac{5}{8}$ to $\frac{3}{4}$ of an inch thick, studded with stout nails, not too thickly. They should be worn with gaiters, so as to keep out dust, stones, etc.

Soft woollen socks, such as those made in Shetland. Of these two or three pairs are required.

A shooting coat, a waistcoat, and trousers of flannel, or of shepherd's plaid, the two former being double-breasted. Flannel should always be worn next the skin on account of rapid changes of temperature on the glaciers and in the valleys.

A light wide-awake hat with strings or elastic band. In very hot weather the action of the sun on the forehead and temples may be diminished by a thick roll of white muslin round the hat.

A light waterproof of silk; one may be got weighing only six ounces.

The contents of the knapsack should not weigh more than 6 or 7 lbs. They should consist of two spare thin merino shirts, three or four pairs of socks, well run in heels and toes, a very thin pair of trousers or drawers for change, two pocket handkerchiefs, and a pair of light shoes; materials for mending—as needles, thread, worsted, tape, buttons, bits of cloth and flannel; also string, soap, sponge, brush and comb, razor, and tooth-brush; oiled-silk, lint, and bandages; ordinary medicine—as compound rhubarb pills, opium, and sugar of lead and opium pills, tartar emetic, lard, and sticking-plaster; a small quantity of note-paper, ink, pens, wafers; a large knife, furnished with a corkscrew, gimlet, and saw; lucifers; a pair of dark spectacles, and a dark veil, and warm gloves and muffitees. There may be also added a journal, a thermometer, compass, clinometer, whistle, and a small telescope. A flask and drinking-cup will also be of service, and a common coarse blouse, which can be procured in Switzerland for two francs. For travelling on glaciers a few screws, about $\frac{3}{4}$ of an inch long, with large double-pointed heads, are useful. Wills procured them at Chamouni. These are screwed into the sole, three or four being enough for each shoe.

For glacier work, stout ropes, thicker than a window-sash cord are required, 10 to 15 feet for each person, and an ice hatchet. An alpenstock, 6 feet in length, is of essential service. A good map is also of great value. The botanist must also have a small tin box, 10 or 12 inches in length, and about 4 deep; a small spade, in a leathern case, fastened round his waist, and a small field-book for drying plants, made of thin wooden boards, 8 or 9 inches long, and about 5 inches broad, and containing drying paper, about 1 or 1½ inch deep. The plants gathered must be transferred to larger drying paper at different stations, and must then either be carried by a porter, or sent by conveyance of some sort.

It is by no means necessary to have guides in every part of the Alps of Switzerland. For instance, Mr. Wills says, that none are required for the Col de Balme, the Tête Noire, the Col de Vose, the Great St. Bernard the Gemmi and the Grimsel. In wandering, however, among the high mountains, it is always safe to take a guide. Wills suggests that the best way is to secure a good guide at starting, and keep him during the whole tour. He costs about five or six francs a day.

1233. *Works on the Microscope.*—The following works may be consulted by the student:—Quekett's Practical Treatise on the Use of the Microscope; Carpenter, The Microscope and its Revelations; Schacht, The Microscope and its Application to Vegetable Anatomy and Physiology, translated by Currey; Hannover on the Construction and Use of the Microscope, edited by Professor Goodsir; Beale, The Microscope and its Application to Clinical Medicine; Hogg on the Microscope; Ross, article "Microscope" in the Penny Cyclopædia; Bennett's Lectures on Clinical Medicine, etc.; Transactions of Microscopical Society and Microscopical Journal; Griffith and Henfrey, Micrographical Dictionary; Pritchard's Microscopic Illustrations; Robin, Du Microscope et des Injections.

1234. *List of the principal Microscope Makers.*—Ross, Powell and Lealand, Smith and Beck, Ladd, Pillischer, Pritchard, Salmon, in London; Adie, Bryson, Hart, in Edinburgh; Field, Parkes, in Birmingham; Dancer, in Manchester; King, in Bristol; Chevalier, Nachet, Oberhäuser, Brunner, in Paris; Schiek, Pistor, in Berlin; Ploesl, in Vienna; Frauenhofer, in Munich; Amici in Modena.

1235. ROSS' MICROSCOPES IN 1855—OBJECTIVES AND PRICES.

Object Glasses, Focal Length.	Angle of Aperture.	Magnifying Powers, with four Eye-pieces.				Prices.	
		A	B	C	D	£	s.
2 inches	12 degs.	20	30	40	60	2	0
1 inch	15 „	60	80	100	120	3	0
1 „	22 „	60	80	100	120	3	10
$\frac{1}{2}$ „	65 „	100	130	180	220	5	5
$\frac{1}{4}$ „	85 „	220	350	500	620	5	5
$\frac{1}{4}$ „	125 „	220	350	500	620	7	10
$\frac{1}{6}$ „	135 „	320	510	700	910	10	0
$\frac{1}{8}$ „	130 „	400	670	900	1200	11	0
$\frac{1}{8}$ „	150 „	400	670	900	1200	12	0
$\frac{1}{12}$ „	170 „	650	900	1250	2000	18	0

1236. *Directions to Collectors visiting Foreign Countries, condensed from Hooker's Kew Miscellany,* Vol. IX., p. 214–219.

A Botanist visiting a foreign country should make as perfect a collection as possible of all the plants, neglecting no species and preserving specimens of every kind, more especially such as seem to be confined to certain localities. The arborescent plants, trees of every description, are to be sought for and collected in flower and in fruit; cones and larger acorns, and other kinds too large for the hortus siccus, are to be preserved apart from the foliage, and notes made of the locality, height, bulk of the trunk, etc. In proportion as mountains are ascended, the vegetation will be found to change and to become more interesting and more peculiar. Particular notice should be taken of the heights at which different plants grow, and of those plants which are found nearest to the limit of perpetual snow. Care should be taken to preserve the collections from wet and damp. They may require to be opened occasionally, and exposed to a dry air or artificial heat. Seeds should be collected, and transported in the way already noticed (¶ 1231). Objects of interest as regards economic botany should be collected; such as articles of food, clothing, ornament, medicines, resins, dye-stuffs, samples of woods, particularly those good for carpentry and cabinet-work. Varieties and abnormal forms of species should be sought for and preserved; attention being paid to differences in habit and in the form of leaves and flowers in the same species at different periods of growth and in different conditions of growth. A comparison should be instituted between the flowers of different regions, as of the plains, swamps, and of different heights and exposures on the mountains, as well of different geological districts, as granite, limestone, etc. The times of leafing and flowering of bushes and trees, etc., should be noticed. When the vegetation seems unusually retarded or accelerated, the temperature of the surface soil and at three feet deep should be ascertained, wherever possible. The collector should, as soon as possible, make himself acquainted with the names of the more common and conspicuous plants of the district he traverses, by consulting any works which may have been written regarding it. The plants which affect waysides or the tracks of man and animals should be noticed, and the effect of clearing away forests and of burning grass land on the subsequent vegetation should be attended to. The transport of seeds by man and animals is a subject of great interest, which should not be neglected. Care should be taken to ticket the specimens, so that there may be no difficulty in determining their localities afterwards. Notes as to elevation (if above 2000 feet of the sea level), dates, name of district, and any other information, should be attached to the specimens to which they refer. A collector cannot be too careful in regard to these matters. Ascertaining the temperature of the trunks of evergreen and deciduous trees and of the soil at their roots is a subject of importance. The temperature of the soil at various depths during winter should be recorded; also the temperature of the air and water between the under surface of melting snow-beds and the subjacent dormant vegetation, with the view of determining the causes of the rapidity with which plants germinate and blossom after the disappearance of snow from alpine situations.*

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* For fuller details see instructions by Sir Wm. Hooker and Dr. Hooker in Kew Miscellany, Vol. ix., pp. 214-219.

GLOSSARY,

OR

EXPLANATION OF SOME OF THE MOST IMPORTANT BOTANICAL TERMS.

A, *alpha*, privative of the Greek, placed before a Greek or Latin word, indicates the absence of the organ; thus, *aphyllus*, leafless, *acaulis*, stemless.

Abaxial or **Abaxile**, not in the axis, applied to the embryo when out of the axis of the seed.

Abnormal, deviating from regularity or from the usual form or structure.

Abortion, suppression of an organ, depending on non-development.

Abrupt, ending in an abrupt manner, as the truncated leaf of the Tulip tree; *abruptly-pinnate*, ending in 2 pinnæ, in other words, paripinnate; *abruptly-acuminate*, a leaf with a broad extremity from which a point arises.

Abscission, cutting off, applied to the separation of the segments or frustules of Diatoms.

Acaulis or **Acaulescent**, without an evident stem.

Accrescent, when parts continue to grow and increase after flowering, as the calyx of Physalis, and the styles of Anemone Pulsatilla.

Accrete, grown together.

Accumbent, applied to the embryo of Cruciferæ, when the cotyledons have their edges applied to the folded radicle.

Acerose, narrow and slender, with a sharp point.

Achene or **Achænium**, a monospermal seed-vessel which does not open, but the pericarp of which is separable from the seed.

Achlamydeous, having no floral envelope.

Achromatic, applied to lenses which prevent chromatic aberration, *i. e.*, show objects without any prismatic colours.

Acicular, like a needle in form.

Aciculus, a strong bristle.

Acinaciform, shaped like a sabre or scimitar.

Acinus, one of the pulpy drupels forming the fruit of the Raspberry or Bramble.

Actinenchyma, cellular tissue, having a star-like or stellate form.

Acotyledonous, having no cotyledons.

Acrocarpi, Mosses having their fructification terminating the axis.

Acrogen and **Acrogenous**, a stem formed by the bases of fronds in ferns, increasing by its summit, and having its vascular tissue in the form of irregularly formed bundles.

Aculeus, a prickle, a process of the bark, not of the wood, as in the Rose; *Aculeate*, furnished with prickles.

Acuminate, drawn out into a long point.

Acute, terminating gradually in a sharp point.

Adelphous or **Adelphia**, in composition, means union of filaments.

Adherent, united, adhesion of parts that are normally separate, as when the calyx is united to the ovary.

Adnate, when an organ is united to another throughout its whole length, as the stipules in Rose, and the filament and anther in Ranunculus.

Adpressed or **Appressed**, closely applied to a surface, as some hairs.

Aduncus, crooked or hooked.

Adventitious, organs produced in abnormal positions, as roots arising from aërial stems.

Æstivation, the arrangement of the parts of the flower in the flower-bud.

Affinity, relation in all essential organs.

Agamous, the same as *Cryptogamous*.

Ala, a wing, applied to the lateral petals of a papilionaceous flower, and to membranous appendages of the fruit, as in the Elm, or of the seed, as in pines.

Albumen, the nutritious matter stored up with the embryo, called also *Perisperm* and *Endosperm*.

Alburnum, the outer young wood of a Dicotyledonous stem.

Algology, the study of Sea-weeds.

Alsinaceous, a polypetalous corolla, in which there are intervals between the petals, as in Chickweed.

Alternate, arranged at different heights on the same axis, as when each leaf is separated by internodes by those next to it.

Alveolæ, regular cavities on a surface, as in the receptacle of the Sunflower, and in that of Nelumbium which is called *Alveolate*.

Amentum, a catkin or deciduous unisexual spike; plants having catkins are *Amentiferous*.

Amnios, the fluid or semi-fluid matter in the embryo-sac.

Amorphous, without definite form.

Amphisarca, an indehiscent multilocular fruit with a hard exterior, and pulp round the seeds, as seen in the Baobab.

Amphitropal, an ovule curved on itself, with the hilum in the middle.

Amplexicaul, embracing the stem over a large part of its circumference.

Ampulla, a hollow leaf, as in Utricularia.

Analogous, when a plant strikingly resembles one of another genus, so as to represent it.

Anastomosis, union of vessels; union of the final ramifications of the veins of a leaf.

Anatropal or **Anatropous**, an inverted ovule, the hilum and micropyle being near each other, and the chalaza at the opposite end.

Anceps, two-edged.

Andrœcium, the male organs of the flower.

Androgynous, male and female flowers on the same peduncle, as in some species of Carex.

Androphore, a stalk supporting the stamens, often formed by a union of the filaments.

Aner, male or stamen, in composition, *Andro* and *Androus*.

Anfractuose, wavy or sinuous, as the anthers of Cucurbitaceæ.

Angienchyma, vascular tissue in general.

Angiospermous, having seeds contained in a seed-vessel.

Anisos, in composition, means unequal.

Anisostemonous, stamens not equal in number to the floral envelopes, nor a multiple of them.

Annotinus, a year old.

Annulus, a ring, applied to the elastic rim surrounding the sporangia of some Ferns, also to a cellular rim on the stalk of the Mushroom, being the remains of the veil.

Anterior, same as *inferior*, when applied to the parts of the flower in their relation to the axis.

Anthela, the cymose panicle of Juncaceæ.

Anther, the part of the stamen containing pollen.

Antheridium, male organ in Cryptogamic plants, frequently containing moving filaments.

Antherozoa, moving filaments in an antheridium.

Anthesis, the opening of the flower.

Anthocarpous, applied to multiple or polygynœcial fruits, formed by the ovaries of several flowers.

Anthodium, the capitulum or head of flowers of Composite plants.

Anthophore, a stalk supporting the inner floral envelopes, and separating them from the calyx.

Anthos, a flower, in composition, *Antho*; in Latin *Flos*.

Anthotaxis, the arrangement of the flowers on the axis.

Anticus, placed in front of a flower, as the lip of Orchids; *Antheræ Anticæ*, anthers which open on the surface next the centre of the flower; same as *Introrse*.

Antitropal, applied to an embryo whose radicle is diametrically opposite to the hilum.

Aperispermic, without separate albumen; same as *Exalbuminous*.

Apetalous, without petals, in other words, monochlamydeous.

Aphyllous, without leaves.

Apical or **Apicilar**, at the apex; often applied to parts connected with the ovary.

Apiculate, having an apiculus.

Apiculus or **Apiculum**, a terminal soft point springing abruptly.

Apocarpous, ovary and fruit composed of numerous distinct carpels.

Apophysis, a swelling at the base of the theca in some Mosses.

Apothecium, the rounded, shield-like fructification of Lichens.

Apterous, without wings.

Arachnoid, applied to fine hairs so entangled as to resemble a cobweb.

Archegonium, the young female cellular organ in Cryptogamic plants.

Arcuate, curved in an arched manner like a bow.

Areolate, divided into distinct angular spaces or *Areolæ*.

Arillus and **Arillode**, an extra covering on the seed, the former proceeding from the placenta, the latter from the exostome, as in Mace.

Arista, an awn, a long pointed process, as in Barley and many grasses which are called *Aristate*.

Armature, the hairs, prickles, &c., covering an organ.

Articulated, jointed, separating easily and cleanly at some point.

Ascending, applied to a procumbent stem which rises gradually from its base; to ovules attached a little above the base of the ovary; and to hairs directed towards the upper part of their support.

Ascidium, a pitcher or folded leaf, as in Nepenthes.

Ascus, a bag, applied to the thecæ of Lichens and other Cryptogams, containing sporidia or spores.

Asperity, roughness, as on the leaves of Boraginaceæ.

Atractenchyma, tissue composed of spindle-shaped cells.

Atropous or **Atropal**, the same as *Orthotropous*.

Auriculate, having appendages, applied to leaves, having lobes or leaflets at their base.

Awn and **Awned**, see *Arista* and *Aristate*.

Axil, the upper angle where the leaf joins the stem.

Axile or **Axial**, belonging to the axis.

Axillary, arising from the axil of a leaf.

Axis, is applied to the central portion of the young plant, whence the plumule and radicle are given off, and the name is given in general to the central organ bearing buds; in Grasses, the common stem of a locusta.

Bacca, berry, a unilocular fruit having a soft outer covering, and seeds immersed in pulp. All such fruits are called *Baccate*.

Balausta, the fruit of the Pomegranate.

Barbate, Bearded, having tufts of hair-like pubescence.

Bark (cortex), the outer cellular and fibrous covering of the stem; separable from the wood in Dicotyledons.

Barren, not fruitful, applied to male flowers, and to the non-fructifying fronds of ferns.

Basal or **Basilar**, attached to the base of an organ.

Basidium, a cell bearing on its exterior one or more spores in some Fungi, which are hence called *Basidiosporous*.

Bast or **Bass**, the inner fibrous bark of Dicotyledonous trees.

Bedeguar, a hairy excrescence on the branches and leaves of Roses, caused by an attack of a Cynips.

Bidentate, having two tooth-like processes.

Bifarious, in two rows, one on each side of an axis.

Bifid, two-cleft, cut down to near the middle into two parts.

Biforine, a raphidian cell with an opening at each end.

Bilamellar, having two lamellæ or flat divisions, as in some stigmas.

Bilocular, having two loculaments.

Binate, applied to a leaf composed of two leaflets at the extremity of a petiole.

Bipartite, cut down to near the base into two parts.

Bipinnate, a compound leaf divided twice in a pinnate manner.

Bipinnatifid, a simple leaf, with lateral divisions extending to near the middle, and which are also similarly divided.

Bipinnatipartite, differing from bipinnatifid in the divisions extending to near the midrib.

Biplicate, doubly folded in a transverse manner.

Biporose, having two rounded openings.

Bis, twice, in composition *Bi*.

Biserrate, or duplicate-serrate, when the serratures are themselves serrate.

Biternate, a compound leaf divided into three, and each division again divided into three.

Bitten, same as *Premorse*.

Blade, the lamina or broad part of a leaf, as distinguished from the petiole or stalk.

Blanching, see *Etiolation*.

Bletting, a peculiar change in an austere fruit, by which, after being pulled, it becomes soft and edible, as in the Medlar.

Bole, the trunk of a tree.

Bothrenchyma, dotted or pitted vessels, with depressions on the inside of their walls.

Brachiate, with decussate branches.

Bract, a leaf more or less changed in form, from which a flower or flowers proceed; flowers having bracts are called *Bracteated*.

Bracteole or **Bractlet**, a small bract at the base of a separate flower in a multifloral inflorescence.

Bryology, the study of Mosses; same as *Muscology*.

Bulb, an underground bud covered with scales.

Bulbil or **Bulblet**, separable buds in the axil of leaves, as in some Lilies.

Bulbous-based, applied to hairs which are tumid at the base.

Byssoid, very slender, like a cobweb.

Caducous, falling off very early, as calyx of Poppy.

Cæspitose, growing in tufts.

Calathiform, hemispherical or concave like a bowl or cup.

Calathium, same as *Capitulum* and *Anthodium*.

Calcar, a spur, a projecting hollow or solid process from the base of an organ, as in the flowers of Larkspur and Snapdragon; such flowers are called *Calcarate* or spurred.

Calceolate, slipper-like, applied to the hollow petals of some Orchids, also to the petals of Calceolaria.

Callosity or **Callus**, a leathery or hardened thickening on a limited portion of an organ.

Calycifloræ, a sub-class of Polypetalous Exogens, having the stamens attached to the calyx.

Calyculus or **Caliculus**, an outer calycine row of leaflets, giving rise to a double or calyculate calyx.

Calyptra, the outer covering of the sporangium of Mosses.

Calyx, the outer envelope of the flower; when there is only one envelope, it is the calyx.

Cambium, mucilaginous cells, between the bark and the young wood, or surrounding the vessels.

Campanulate, shaped like a bell, as the flower of Hare-bell.

Campulitropal or **Campylotropal**, a curved ovule with the hilum, micropyle, and chalaza near each other.

Canaliculate, channelled, having a longitudinal groove or furrow.

Cancellate, latticed, composed of veins alone.

Capillary, filiform, thread-like or hair-like.

Capitate, pin-like, having a rounded summit, as some hairs.

Capitulum, head of flowers in Compositæ.

Capreolate, having tendrils.

Caprification, the ripening of the Fig, by means of the wild fig or Caprificus.

Capsula Circumscissa, same as *Pyxis* or *Pyxidium*.

Capsule, a dry seed-vessel, opening by valves, teeth, pores, or a lid.

Carina, keel, the two partially united lower petals of papilionaceous flowers.

Carinal, applied to æstivation when the carina embraces the other parts of the flower.

Carnose, fleshy, applied to albumen having a fleshy consistence.

Carpel or **Carpidium**, the leaf forming the pistil. Several carpels may enter into the composition of one pistil.

Carpology, the study of fruits.

Carpophore, a stalk bearing the pistil, and raising it above the whorl of the stamens, as in Lychnis and Capparis.

Carpos, fruit, in composition *Carpo*.

Caruncula, a fleshy or thickened appendage of the seed.

Caryopsis or **Cariopsis**, the monospermal seed-vessel of Grasses, the pericarp being incorporated with the seed.

Cassideous, shaped like a helmet.

Catkin, same as *Amentum*.

Caudate, having a tail or feathery appendage.

CAUDEX, the stem of Palms and of Tree-ferns.

CAUDICLE, CAUDICULA, the process supporting a pollen-mass in Orchids.

CAULESCENT, having an evident stem.

CAULICLE, CAULICULUS, a stalk connecting the axis of the embryo and the cotyledons.

CAULIS, an aerial stem.

CELLULOSE, the chemical substance of which the cell-wall is composed.

CENTIMETRE, a French measure, equal to 0.3937079 British inch.

CENTRIFUGAL, applied to that kind of inflorescence in which the central flower opens first.

CENTRIPETAL, applied to that kind of inflorescence in which the flowers at the circumference or base open first.

CERAMIDIUM, an ovate conceptacle having a terminal opening, and with a tuft of spores arising from the base; seen in Algæ.

CERATIUM, a siliquæform capsule in which the lobes of the stigma are alternate with the placenta, as in Glaucium.

CEREAL, applied to Wheat, Oats, Barley, and other grains.

CERNUOUS, pendulous, nodding.

CHALAZA, the place where the nourishing vessels enter the nucleus of the ovule.

CHLAMYS, covering, applied to the floral envelope, in composition *Chlamydeous*.

CHLOROPHYLL, the green colouring matter of leaves.

CHLOROS, green, in composition *Chloro*.

CHORISIS or CHORIZATION, separation of a lamina from one part of an organ so as to form a scale or a doubling of the organ; it may be either transverse or collateral.

CHROMA, colour, in composition *Chrom*.

CHROMOGEN and CHROMULE, the colouring matter of flowers.

CHRYSOS means yellow like gold, in composition *Chryso*.

CICATRICULA, the scar left after the falling of a leaf; also applied to the hilum or base of the seed.

CILIA (Cilium), short stiff hairs fringing the margin of a leaf; also delicate vibratile hairs of zoospores.

CINENCHYMA, laticiferous tissue, formed by anastomosing vessels.

CIRCINATE, rolled up like a crozier, as the young fronds of Ferns.

CIRCUMSCISSILE, cut round in a circular manner, such as seed-vessels opening by a lid.

CIRCUMSCRIPTION, the periphery or margin of a leaf.

CIRRHUS, a tendril, or modified leaf in the form of a twining process.

CLADENCHYMA, tissue composed of branching cells.

CLADOS, a branch, in composition *Clado*.

CLATHRATUS, latticed like a grating.

CLAVATE, club-shaped, becoming gradually thicker towards the top.

CLAW, the narrow base of some petals, corresponding to the petiole of leaves.

CLEFT, divided to about the middle.

CLINANDRIUM, the part of the column of Orchids bearing the anther.

CLINANTHIUM, the common receptacle of the flowers of Compositæ.

CLINE, a bed, in composition *Clin*, used in reference to parts on which the floral organs are inserted.

CLOVES, applied to young bulbs, as in the Onion.

CLYPEATE, having the shape of a buckler.

COCCIDIUM, a rounded conceptacle in Algæ without pores, and containing a tuft of spores.

COCCUS and COCCUM, applied to the portions composing the dry elastic fruit of Euphorbiaceæ.

COCHLEAR, a kind of æstivation, in which a helmet-shaped part covers all the others in the bud.

COCHLEARIFORM, shaped like a spoon.

COLEORHIZA, a sheath covering the radicle of a monocotyledonous embryo.

COLLATERAL, placed side by side, as in the case of some ovules.

COLLENCHYMA, the inter-cellular substance which unites cells.

COLLUM, neck, the part where the plumule and radicle of the embryo unite.

COLPENCHYMA, tissue composed of wavy or sinuous cells.

COLUMELLA, central column in the sporangia of Mosses; also applied to the carpophore of Umbelliferæ.

COLUMN, a part in the flower of an Orchid supporting the anthers and stigma, and formed by the union of the styles and filaments.

COMA, applied variously, to tufts of hairs, to bracts occurring beyond the inflorescence, and to the general arrangement of the leaf-bearing branches of a tree, &c.

COMMISSURE, union of the faces of the two achenes in the fruit of Umbelliferæ.

COMOSE, furnished with hairs, as the seeds of the Willow.

COMPOUND, composed of several parts, as a leaf formed by several separate leaflets, or a pistil formed by several carpels either separate or combined.

COMPRESSED, flattened laterally or lengthwise.

CONCEPTACLE, a hollow sac containing a tuft or cluster of spores.

CONDUCTING TISSUE, applied to the loose cellular tissue in the interior of the canal of the style.

CONDUPLICATE, folded upon itself, applied to leaves and cotyledons.

CONE, a dry multiple fruit, formed by bracts covering naked seeds.

CONENCHYMA, conical cells, as hairs.

CONFERVOID, formed of a single row of cells, or having articulations like a Conferva.

CONFLUENT, when parts unite together in the progress of growth.

CONJUGATION, union of two cells, so as to develope a spore.

CONNATE, when parts are united even in the early state of development; applied to two leaves united by their bases.

CONNECTIVE, the part which connects the anther lobes.

CONNIVENT, when two organs, as petals, arch over so as to meet above.

CONTORTED, when the parts in a bud are imbricated and regularly twisted in one direction

CONVOLUTE or **CONVOLUTIVE**, when a leaf in the bud is rolled upon itself.

CORALLINE, like Coral, as the root of Corallorhiza.

CORCULUM, a name for the embryo.

CORD, the process which attaches the seed to the placenta.

CORDATE, heart-shaped, a plane body with the division or broad part of the heart next the stalk or stem.

CORDIFORM, a solid body having the shape of a heart

CORIACEOUS, having a leathery consistence.

CORM, thickened underground stem, as in the Colchicum and Arum.

CORMOGENÆ, having a corm or stem.

CORNU, a horn; *Corneous*, having the consistence of horn; *Bicornis* or *Bicornute*, having two horns.

COROLLA, the inner envelope of the flower.

COROLLIFLORÆ, Gamopetalous Exogens, with hypogynous stamens.

CORONA, a corolline appendage, as the crown of the Daffodil.

CORRUGATED, wrinkled or shrivelled.

CORTEX, the bark; *Cortical*, belonging to the bark; *Corticated*, having a bark.

CORTINA, the remains of the veil which continue attached to the edges of the pileus in Agarics.

CORYMB, a raceme in which the lower stalks are longest, and all the flowers come nearly to a level above; *Corymbiferous* or *Corymbose*, bearing a corymb, or in the form of a corymb.

COSTA, a rib, applied to the prominent bundles of vessels in the leaves; *Costate*, provided with ribs.

COTYLEDON, the temporary leaf or lobe of the embryo.

CRAMPONS, a name given to adventitious roots which serve as fulcra or supports, as in the Ivy.

CREMOCARP, the fruit of Umbelliferæ, composed of two separable achenes or mericarps.

CRENATE, having superficial rounded marginal divisions.

CRENATURES, divisions of the margin of a crenate leaf.

CREST, an appendage to fruits or seeds, having the form of a crest.

CRISP, having an undulated margin.

CROWN OF THE ROOT, the short stem which is at the upper part of the root of perennial herbs.

CRUCIFORM and **CRUCIATE**, arranged like the parts of a cross, as flowers of Cruciferæ.

CRUSTACEOUS, hard, thin, and brittle; applied to those Lichens which are hard and expanded like a crust.

CRYTOGAMOUS, organs of reproduction obscure.

CRYPTOS, inconspicuous or concealed, in composition *Crypto*.

CUCULLATE, formed like a hood.

CULM, stem or stalk of grasses.

CUNEIFORM or **CUNEATE**, shaped like a wedge standing upon its point.

CUPULA, the cup of the acorn, formed by aggregated bracts.

CURVEMBRYEÆ, with the embryo curved.

CUSPIS, a long point large at the base, and gradually attenuated; *Cuspidate*, prolonged into a cuspis, abruptly acuminate.

CUTICLE, the thin layer that covers the epidermis.

CYATHIFORM, like a wine-glass; concave, in the form of a reversed cone.

CYCLOOENS, applied to Dicotyledons with concentric woody circles.

CYCLOSIS, movement of the latex in laticiferous vessels.

CYLINDRENCHYMA, tissue composed of cylindrical cells

CYMBIFORM, shaped like a boat.

CYME, a kind of definite inflorescence, in which the flowers are in racemes, corymbs, or umbels, the successive central flowers expanding first; *Cymose*, inflorescence in the form of a cyme.

CYPSELA, monospermal fruit of Compositæ.

CYSTIDIA, sacs containing spores; a kind of fructification in Fungi.

CYTOBLAST, the nucleus of a cell.

CYTOBLASTEMA, mucilaginous formative matter of cells, called also *Protoplasm*.

CYTOGENESIS, cell-development.

CYTOS, a cell, in composition *Cyto*.

DÆDALENCHYMA, entangled cells.

DECA, ten, in Greek words, same as the Latin *Decem;* as *decandrous*, having ten stamens; *decagynous*, having ten styles.

DECIDUOUS, falling off after performing its functions for a limited time, as calyx of Ranunculus.

DECIDUOUS TREES, which lose their leaves annually.

DECIMETRE, the tenth part of a metre or ten centimetres.

DECLINATE or **DECLINING**, directed downwards from its base, applied to stamens of Amaryllis.

DECOMPOUND, a leaf cut into numerous compound divisions.

DECORTICATED, deprived of bark.

DECUMBENT, lying flat along the ground, and rising from it at the apex.

DECURRENT, leaves which are attached along the side of a stem below their point of insertion. Such stems are often called *Winged*.

DECUSSATE, opposite leaves crossing each other in pairs at right angles.

DEDUPLICATION, same as *Chorisis*.

DEFINITE, applied to inflorescence when it ends in a single flower, and the expansion of the flower is centrifugal; also when the number of the parts of an organ is limited, as when the stamens are under twenty.

DEFLEXED, bent downwards in a continuous curve.

DEFOLIATION, the fall of the leaves.

DEGENERATION, when an organ is changed from its usual appearance and becomes less highly developed, as when scales take the place of leaves.

DEHISCENCE, mode of opening of an organ, as of the seed-vessel and anther.

DELTOID, like the Greek Δ in form, properly applied solely to describe the transverse section of solids.

DENTATE, toothed, having short triangular divisions of the margin. The term is also applied to the superficial divisions of a gamosepalous calyx and a gamopetalous corolla.

DENTICULATE, finely-toothed, having small tooth-like projections along the margin.

DEPRESSED, flattening of a solid organ from above downwards.

DETERMINATE, applied to definite or cymose inflorescence.

DEXTRORSE, directed towards the right.

DIACHÆNIUM, same as *Cremocarp*, fruit composed of two achenes.

DIACHYMA, the parenchyma of the leaf.

DIADELPHOUS, stamens in two bundles, united by their filaments.

DIALYCARPOUS, pistil or fruit composed of distinct (separate) carpels.

DIALYPETALOUS, corolla composed of separate petals.

DIALYSEPALOUS or DIALYPHYLLOUS, calyx composed of separate sepals.

DICHLAMYDEOUS, having calyx and corolla.

DICHOTOMOUS, stem dividing by twos.

DICLINOUS, unisexual flowers, either monœcious or diœcious.

DICOTYLEDONOUS, embryo having two cotyledons.

DICTYOGENOUS, applied to monocotyledons having netted veins.

DIDYMOUS, twice, union of two similar organs.

DIDYNAMOUS, two long and two short stamens.

DIGITATE, compound leaf composed of several leaflets attached to one point.

DIGYNOUS, having two styles.

DILAMINATION, same as *Deduplication* and *Chorisis*.

DIMEROUS, composed of two pieces.

DIMIDIATE, split into two on one side, as the calyptra of some Mosses.

DIMORPHOUS, when similar parts of a plant assume different forms.

DIŒCIOUS, staminiferous and pistilliferous flowers on separate plants.

DIPLECOLOBEÆ, cotyledons twice folded transversely.

DIPLOOS, double, in composition *Diplo*.

DIPLOPERISTOMI, Mosses with a double peristome.

DIPLOSTEMONOUS, stamens double the number of the petals or sepals.

DIPTEROUS, having two wings.

DIS, twice in composition, *Di*, same as Latin *Bis* or *Bi*; as *disepalous*, having two sepals, *dispermous*, two seeded.

DISCIFORM and DISCOID, in the form of a disc or flattened sphere; *discoid pith*, divided into cavities by discs.

DISCOID, also applied to the flosculous or tubular flowers of Compositæ.

DISCS, the peculiar rounded and dotted markings on coniferous wood.

DISK, a part intervening between the stamens and the pistil in the form of scales, a ring, etc.

DISPERMOUS, having two seeds.

DISSECTED, cut into a number of narrow divisions.

DISSEPIMENT, a division in the ovary; *true*, when formed by edges of the carpels; *false*, when formed otherwise.

DISSILIENT, applied to fruit which bursts in an elastic manner.

DISTICHOUS, in two rows, on opposite sides of a stem.

DISTRACTILE, separating two parts to a distance from each other.

DITHECAL, having two loculaments.

DIVARICATING, branches coming off from the stem at a very wide or obtuse angle.

DODECA, twelve; in Latin *Duodecim*.

DODECAGYNOUS, having twelve pistils.

DODECANDROUS, having twelve stamens.

DOLABRIFORM, shaped like an axe.

DORSAL, applied to the suture of the carpel which is farthest from the axis.

DORSIFEROUS, Ferns bearing fructification on the back of their fronds.

DORSUM, the back, the part of the carpel which is farthest from the axis.

DOUBLE FLOWER, when the organs of reproduction are converted into petals.

DRUPE, a fleshy fruit like the Cherry, having a stony endocarp. *Drupels*, small drupes aggregated to form a fruit, as in the Raspberry.

DUMOSE, having a low shrubby aspect.

DURAMEN, heart-wood of Dicotyledonous trees.

DYNAMIS, power, in composition means superiority in length; as *didynamous*, two stamens longer than two others.

E or EX, in composition corresponds to alpha privative; as *ebracteated*, without bracts; *exaristate*, without awns; *edentate*, without teeth; *ecostate*, without ribs.

ELATERS, spiral fibres in the spore-cases of Hepaticæ.

ELLIPTICAL, having the form of an ellipse.

EMARGINATE, with a superficial portion taken out of the end.

EMBRYO, the young plant contained in the seed.

EMBRYO-BUDS, nodules in the bark of the Beech and other trees.

EMBRYOGENY, the development of the embryo in the ovule.

EMBRYOLOGY, the study of the formation of the embryo.

EMBRYO-SAC or EMBRYONARY-SAC, the cellular bag in which the embryo is formed.

EMBRYOTEGA, a process raised from the spermoderm by the embryo of some seeds during germination, as in the Bean.

ENDECA, in Greek, eleven; in Latin, *undecim*.

ENDECAGYNOUS, having eleven pistils.

ENDECANDROUS, having eleven stamens.

ENDOCARP, the inner layer of the pericarp next the seed.

ENDOCHROME, the colouring matter of cellular plants.

ENDOGEN, an inside grower, having an endogenous stem.

ENDON, within or inwards, in Composition *Endo*.

ENDOPHLŒUM, the inner bark or liber.

ENDOPLEURA, the inner covering of the seed.

ENDORHIZAL, numerous rootlets arising from a common radicle, and passing through sheaths as in endogenous germination.

ENDOSMOSE, movement of fluids inwards, through a membrane.

ENDOSPERM, albumen formed within the embryo-sac.

Endosporous, Fungi having their spores contained in a case.
Endostome, the inner foramen of the ovule.
Endothecium, the inner coat of the anther.
Enervis, without veins.
Ennea, nine; in Latin *Novem*.
Enneagynous, having nine pistils.
Enneandrous, having nine stamens.
Ensiform, in the form of a sword, as the leaves of Iris.
Entire (*integer*), without marginal divisions; (*integerrimus*), without either lobes or marginal divisions.
Envelopes, Floral, the calyx and corolla.
Epi, upon, in composition, means on the outside or above, as *epicarp*, the outer covering of the fruit; *epigynous*, above the ovary.
Epicalyx, outer calyx, formed either of sepals or bracts, as in Mallow and Potentilla.
Epicarp, the outer covering of the fruit.
Epichilium, the label or terminal portion of the strangulated or articulated lip (labellum) of Orchids.
Epicorolline, inserted upon the corolla.
Epidermis, the cellular layer covering the external surface of plants.
Epigeal, above ground, applied to cotyledons.
Epigone, the cellular layer which covers the young sporangium in Mosses and Hepaticæ.
Epigynous, above the ovary by adhesion to it.
Epipetalous, inserted upon the petals.
Epiphragm, the membrane closing the orifice of the thecæ of some Mosses.
Epiphyllous, growing upon a leaf.
Epiphyte, attached to another plant, and growing suspended in the air.
Epirrheology, the influence of external agents on living plants.
Episperm, the external covering of the seed.
Epispore, the outer covering of some spores.
Equitant, applied to leaves folded longitudinally, and overlapping each other without any involution.
Erect, applied to an ovule which rises from the base of the ovary; also applied to innate anthers.
Erose, irregularly toothed, as if gnawed.
Erumpent, prominent, as if bursting through the epidermis, as seen in some tetraspores.
Etærio, the aggregate drupes forming the fruit of Rubus.
Etiolation, blanching, losing colour in the dark.
Exalbuminous, without a separate store of albumen or perisperm.
Exannulate, without a ring, applied to some Ferns.
Excentric, removed from the centre or axis; applied to a lateral embryo.
Excipulus, a receptacle containing fructification in Lichens.
Excurrent, running out beyond the edge or point.
Exintine, one of the inner coverings of the pollen-grain.
Exo, in composition, on the outside.
Exogen, outside grower, same as Dicotyledon.
Exorhizal, radicle proceeding directly from the axis, and afterwards branching, as in Exogens.
Exosmose, the passing outwards of a fluid through a membrane.
Exosporous, Fungi having naked spores.
Exostome, the outer opening of the foramen of the ovule.
Exothecium, the outer coat of the anther.
Exserted, extending beyond an organ, as stamens beyond the corolla.
Exstipulate, without stipules.
Extine, the outer covering of the pollen-grain.
Extra-axillary, removed from the axil of the leaf, as in the case of some buds.
Extrorse, applied to anthers which dehisce on the side farthest removed from the pistil.
Exutive, applied by Miers to seeds wanting the usual integumentary covering, as in Olacaceæ.

Falcate or **Falciform**, bent like a sickle.
Farinaceous, mealy, containing much starch.
Fasciation, union of branches of stems, so as to present a flattened riband-like form.
Fascicle, a shortened umbellate cyme, as in some species of Dianthus.
Fastigiate, having a pyramidal form, from the branches being parallel and erect, as Lombardy Poplar.
Favella, a kind of conceptacle in Algæ.
Favellidia, spherical masses of spores usually contained in sacs called capsules.
Feather-veined, a leaf having the veins passing from the midrib at a more or less acute angle, and extending to the margin.
Fenestrate, applied to a replum or leaf with openings in it, compared to windows.
Fertile, applied to pistillate flowers; and to the fruit-bearing frond of Ferns.
Fibro-cellular tissue, composed of spiral cells.
Fibrous, composed of numerous fibres, as some roots.
Fibro-vascular tissue, composed of vessels containing spiral and other fibres.
Fid, in composition, cleft, cut down to about the middle.
Filament, stalk supporting the anther.
Filamentous, a string of cells placed end to end.
Filiform, like a thread.
Fimbriated, fringed at the margin.
Fissiparous, dividing spontaneously into two parts, by means of a septum.
Fissure, a straight slit in an organ for the discharge of its contents.
Fistulous, hollow, like the stem of Grasses.
Flabelliform, fan-shaped, as the leaves of some Palms.
Flagellum, a runner, a weak, creeping stem bearing rooting buds at different points, as in the Strawberry.
Flexuose or **Flexuous**, having alternate curvations in opposite directions; bent in a zig-zag manner.
Flocci, woolly filaments with sporules in Fungi and Algæ.
Floccose, covered with wool-like tufts.
Floral Envelopes, the calyx and corolla.
Flosculous, the tubular florets of Compositæ.
Foliation, the development of leaves.
Foliola, same as *Phylla* and *Sepala*.
Follicle, a fruit formed by a single carpel, de-

hiscing by one suture, which is usually the ventral.

Foot, French, equal to 1.07892 foot British.

Foramen, the opening in the coverings of the ovule.

Foveate or **Foveolate**, having pits or depressions called foveæ or foveolæ.

Fovilla, minute granular matter in the pollen-grain.

Frond, the leaf-like organ of Ferns bearing the fructification; also applied to the thallus of many Cryptogamics.

Frondose, applied to Cryptogams with foliaceous or leaf-like expansions.

Frustules, the parts or fragments into which Diatomaceæ separate.

Frutex, a shrub; *Fruticose*, shrubby.

Fugacious, evanescent, falling off early, as the petals of Cistus.

Fulvous, tawny-yellow.

Funiculus, the umbilical cord connecting the hilum of the ovule to the placenta.

Furcate, divided into two branches, like a two-pronged fork.

Furfuraceous, scurfy or scaly.

Fusiform, shaped like a spindle.

Galbulus, the polygynœcial succulent fruit of Juniper.

Galea, applied to a sepal or petal shaped like a helmet; the part is called *Galeate*.

Gamo, in composition, means union of parts.

Gamopetalous, same as *Monopetalous*, petals united.

Gamophyllous and **Gamosepalous**, same as *Monophyllous* and *Monosepalous*, sepals united.

Geminate, twin organs combined in pairs, same as *Binate*.

Gemma, a leaf-bud; *Gemmation*, the development of leaf-buds.

Gemmiferous, bearing buds.

Gemmiparous, reproduction by buds.

Gemmule, same as *Plumule*, the first bud of the embryo.

Geniculate, bent like a knee.

Germen, a name for the ovary.

Germinal Vesicle, a cell contained in the embryo sac, from which the embryo is developed.

Germination, the sprouting of the young plant.

Gibbosity, a swelling at the base of an organ, such as the calyx or corolla.

Gibbous, swollen at the base, or having a distinct swelling at some part of the surface.

Glabrous, smooth, without hairs.

Gland, an organ of secretion consisting of cells, and generally occurring on the epidermis of plants.

Glandular Hairs, hairs tipped with a gland, as in Drosera and Chinese Primrose.

Glans, nut, applied to the Acorn and Hazel-nut, which are enclosed in bracts.

Glaucous, covered with a pale-green bloom.

Globule, male organ of Chara.

Glochidiate, barbed, applied to hairs with two reflexed points at their summit.

Glomerulus, a rounded, cymose inflorescence, as in Urtica.

Glossology, explanation of technical terms.

Glumaceous, of the nature of glumes.

Glume, a bract covering the organs of reproduction in the spikelets of Grasses, which are hence called *Glumiferous*.

Glumelle and **Glumellule**, a name applied to the palea or pale of a Grass.

Gonidia, green germinating cells in the thallus of Lichens.

Gonus or **Gonum**, in composition, means either kneed or angled; in the former case the o is short, in the latter long. *Polygonum*, many-kneed; *Tetragonum*, four-angled.

Grain, caryopsis, the fruit of Cereal Grasses.

Grains of pollen, minute cells composing the pollen.

Granules, minute bodies and varying greatly in size, having a distinct external shadowed ring or margin, the external edge of which is abrupt.

Granulated, composed of granules.

Grumous, collected into granular masses.

Gymnogen, a plant with naked seeds, *i.e.*, seeds not in a true ovary.

Gymnos, naked, in composition *Gymno*.

Gymnospermous, plants with naked seeds, *i.e.*, seeds not in a true ovary, as Coniferæ.

Gymnospore, a naked spore; *Gymnosporous*, having naked spores.

Gymnostomi, naked-mouthed, Mosses without a peristome.

Gynandrous, stamen and pistil united in a common column, as in Orchids.

Gyne, female, and **Gyn**, **Gynous**, and **Gyno**, in composition, refer to the pistil or the ovary.

Gynizus, the position of the stigma on the column of Orchids.

Gynobase, a central axis to the base of which the carpels are attached.

Gynœcium, the female organs of the flower.

Gynophore, a stalk supporting the ovary.

Gynostemium, column in Orchids bearing the organs of reproduction.

Gyrate, same as *Circinate*.

Gyration, same as *Rotation* in cells.

Habit of a plant, its general external appearance.

Halophytes, plants of salt-marshes, containing salts of soda in their composition.

Hastate, halbert-shaped, applied to a leaf with two portions at the base projecting more or less completely at right angles to the blade.

Haulm, dead stems of herbs, as of the potato.

Haustorium, the sucker at the extremity of the parasitic root of Dodder.

Heart-wood, same as *Duramen*.

Helicoidal, having a coiled appearance like the shell of a snail, applied to inflorescence.

Helmet, the upper petaloid sepal of Aconitum.

Hemi, half; same as Latin *Semi*.

Hemicarp, one of the achenes forming the cremocarp of Umbelliferæ.

Hepta, seven; same as Latin *Septem*.

Heptagynous, having seven styles.

Heptandrous, having seven stamens.

Herb, a plant with an annual stem, opposed to a woody plant.

Herbaceous, green succulent plants which die down to the ground in winter; annual shoots, green-coloured cellular parts.

HERMAPHRODITE, stamens and pistil in the same flower.

HESPERIDIUM, the fruit of the Orange, and other Aurantiaceæ.

HETEROCEPHALOUS, Composite plants having male and female capitula on the same plant.

HETEROCYSTS, peculiar cells forming large germs in Nostochineæ.

HETERODROMOUS, running in different directions.

HETEROGAMOUS, Composite plants having hermaphrodite and unisexual flowers on the same head.

HETEROPHYLLOUS, presenting two different forms of leaves.

HETERORHIZAL, rootlets proceeding from various points of a spore during germination.

HETEROS, dissimilar or diverse, in composition *Hetero.*

HETEROTROPAL, ovule with the hilum in the middle, and the foramen and chalaza at opposite ends.

HEXA, six; same as Latin *Sex.*

HEXAGYNOUS, having six styles.

HEXANDROUS, having six stamens.

HILUM, the base of the seed to which the placenta is attached either directly or by means of a cord. The term is also applied to the mark at one end of some grains of starch.

HIRSUTE, covered with long stiff hairs.

HISPID, covered with long very harsh hairs.

HISTOLOGY, the study of microscopic tissues.

HOLOSERICEOUS, covered with minute silky hairs, discovered better by the touch than by sight.

HOMODROMOUS, running in the same direction.

HOMOGAMOUS, Composite plants having the flowers of the capitula all hermaphrodite.

HOMOGENEOUS, having a uniform structure or substance.

HOMOS and HOMOIOS, similar, in composition *Homo.*

HOMOTROPAL, when the slightly curved embryo has the same general direction as the seed.

HOROLOGICAL, flowers opening and closing at certain hours.

HUMIFUSE, spreading along the ground.

HYALINE, transparent or colourless, applied by Barry to the part where the cell-nucleus appears.

HYBRID, a plant resulting from the fecundation of one species by another.

HYMENIUM, the part which bears the fructification in Agarics.

HYPANTHODIUM, the receptacle of Dorstenia, bearing many flowers.

HYPHASMA, a web-like thallus of Agarics.

HYPO, under or below, in composition *Hyp.*

HYPOCARPOGEAN, plants producing their fruit below ground.

HYPOCHILIUM, the lower part of the labellum of Orchids.

HYPOCRATERIFORM, shaped like a salver, as the corolla of Primula.

HYPOGEAL or HYPOGEOUS, under the surface of the soil, applied to cotyledons.

HYPOGYNOUS, inserted below the ovary or pistil

HYPOTHALLUS, the mycelium of certain Entophytic Fungi as Uredines.

HYPSOMETRICAL, measurement of altitude.

HYSTERANTHOUS, when leaves expand after the flowers have opened.

ICOSANDRIA, having twenty stamens or more inserted on the calyx; *Icosandrous,* having twenty stamens.

ICOSI, twenty; in composition *Icos.* Same as Latin *Viginti.*

IMBRICATE or IMBRICATED, parts overlying each other like tiles on a house. *Imbricated æstivation,* the parts of the flower-bud alternately overlapping each other and arranged in a spiral manner.

IMPARI-PINNATE, unequally-pinnate, pinnate leaf ending in an odd leaflet.

INARCHING, a mode of grafting by bending two growing plants towards each other, and causing a branch of the one to unite to the other.

INARTICULATE, without joints or interruption to continuity.

INCH, French, is equal to 1.06578 inch British.

INCISED, cut down deeply.

INCLUDED, applied to the stamens when enclosed within the corolla, and not pushed out beyond its tube.

INCUMBENT, cotyledons with the radicle on their back.

INDEFINITE, applied to inflorescence with centripetal expansion; also to stamens above twenty, and to ovules and seeds when very numerous.

INDEHISCENT, not opening; having no regular line of suture.

INDETERMINATE, applied to indefinite inflorescence.

INDIGENOUS, an aboriginal native in a country.

INDUPLICATE or INDUPLICATIVE, edges of the sepals or petals turned slightly inwards in æstivation.

INDUSIUM, epidermal covering of the fructification in some Ferns.

INDUTIVE, applied by Miers to seeds having the usual integumentary covering.

INERMIS, unarmed, without prickles or thorns.

INFERIOR, applied to the ovary when it seems to be situated below the calyx; and to the part of a flower farthest from the axis.

INFLORESCENCE, the mode in which the flowers are arranged on the axis.

INFUNDIBULIFORM, in shape like a funnel; as seen in some gamopetalous corollas.

INNATE, applied to anthers when attached to the top of the filament.

INNOVATIONS, buds in Mosses.

INTERCELLULAR SPACE, same as *Lacuna.*

INTERFOLIAR, between two opposite leaves.

INTERNODE, the portion of the stem between two nodes or leaf-buds.

INTERPETIOLAR, between the petioles of opposite leaves; as the stipules of Cinchona.

INTERRUPTEDLY-PINNATE, a pinnate leaf in which pairs of small pinnæ occur between the larger pairs.

INTEXTINE, one of the inner coverings of the pollen-grain.

INTINE, the inner covering of the pollen-grain.

INTRORSE, applied to anthers which open on the side next the pistil.

INVOLUCEL, bracts surrounding the partial umbel of Umbelliferæ.

Involucre, bracts surrounding the general umbel in Umbelliferæ, the heads of flowers in Compositæ, and in general any verticillate bracts surrounding numerous flowers. It is also used in the same sense as the Indusium of Ferns.

Involute or Involutive, edges of leaves rolled inwards spirally on each side, in æstivation.

Irregular, a flower in which the parts of any of the verticils differ in size.

Isocheimal or Isocheimonal, lines passing through places which have the same mean winter temperature.

Isomeric, applied chemically to substances which, though differing in qualities, have the same elements in the same proportions.

Isomerous, when the organs of a flower are composed each of an equal number of parts.

Isos, equal, in composition *Iso.*

Isostemonous, when stamens and floral envelopes have the same number of parts or multiples.

Isotheral, lines passing through places which have the same mean summer temperature.

Isothermal, lines passing through places which have the same mean annual temperature.

Juga, a name given to the ribs on the fruit of Umbelliferæ.

Jugum, a pair of leaflets; *jugate*, applied to the pairs of leaflets in compound leaves; *unijugate*, one pair; *bijugate*, two pairs, and so on.

Keel, same as *Carina*.

Knotted, when a cylindrical stem is swollen at intervals into knobs.

Label, the terminal division of the lip of the flower in Orchids.

Labellum, lip, one of the divisions of the inner whorl of the flower of Orchids. This part is in reality superior, but becomes inferior by the twisting of the ovary.

Labiate, lipped, applied to irregular gamopetalous flowers, with an upper and under portion separated more or less by a hiatus or gap.

Laciniated, irregularly cut into narrow segments.

Lacinula, the small inflexed point of the petals of Umbelliferæ.

Lactescent, yielding milky juice.

Lacuna, a large space in the midst of a group of cells.

Lævigatus, having a smooth polished appearance.

Lævis, even.

Lamellæ, gills of an Agaric, also applied to flat divisions of the stigma.

Lamina, the blade of the leaf, the broad part of a petal or sepal.

Lanceolate, narrowly elliptical, tapering to each end.

Lanuginous, woolly, covered with long flexuous interlaced hairs.

Lateral, arising from the side of the axis, not terminal.

Latex, granular fluid contained in laticiferous vessels.

Laticiferous, vessels containing latex, which anastomose.

Latiseptæ, Cruciferous plants having a broad replum in their silicula.

Legume, a pod composed of one carpel, opening usually by ventral and dorsal suture, as in Pea.

Lenticel, a small process on the bark of the Willow and other plants, whence adventitious roots proceed.

Lenticular, in the form of a doubly-convex lens.

Lepidote, covered with scales or scurf; *Lepis*, a scale.

Lianas or Lianes, twining woody plants.

Liber, the fibrous inner bark or endophlœum.

Lieberkuhn, a metallic mirror attached to the objective of a microscope for the purpose of throwing down light on opaque objects.

Lignine, woody matter which thickens the cell-walls.

Ligulate, strap-shaped florets, as in Dandelion.

Ligule, a process arising from the petiole of grasses where it joins the blade.

Ligulifloræ, Composite plants having ligulate florets.

Limb, the blade of the leaf; the broad part of a petal or sepal; when sepals or petals are united, the combined broad parts are denominated collectively the limb.

Line, the 12th part of an inch; *Ligne*, French, is equal to 0.088815 inch British.

Linear, very narrow leaves, in which the length exceeds greatly the breadth.

Lirella, sessile linear apothecium of Lichens.

Lobe, large division of a leaf or any other organ; applied often to the divisions of the anther.

Loculicidal, fruit dehiscing through the back of the carpels.

Loculus or Loculament, a cavity in an ovary, which is called *unilocular* when it has one cavity, *bilocular* with two, and so on. The terms are also applied to the anther.

Locusta, a spikelet of grasses formed of one or several flowers.

Lodicule, a scale at the base of the ovary of Grasses.

Lomentum and Lomentaceous, applied to a legume or pod with transverse partitions, each division containing one seed.

Lunate, crescent-shaped.

Lyrate, a pinnatifid leaf with a large terminal lobe, and smaller ones as we approach the petiole.

Macropodous, applied to the thickened radicle of a monocotyledonous embryo.

Macros, large, in composition *Macro*.

Malpighiaceous Hairs, peltate hairs, such as are seen in Malpighiaceæ.

Manicate, applied to scales surrounding a stalk like a frill, and easily removed.

Marcescent, withering, but not falling off until the part bearing it is perfected.

Marginate, applied to calyx, same as *Ciliate*.

Masked, same as *Personate*.

Math, a term sometimes used for crop; an agricultural term.

Mattulla, the fibrous matter covering the petioles of Palms.

Medulla, the cellular pith.

Medullary Rays or **Plates**, cellular prolongations uniting the pith and the bark.

Medullary Sheath, sheath containing spiral vessels surrounding the pith in Exogens.

Meiostemonous or **Miostemonous**, the stamens less in number than the parts of the corolla.

Membranaceous or **Membranous**, having the consistence, aspect, and structure of a membrane.

Meniscus, a lens having a concave and a convex face, with a sharp edge.

Merenchyma, tissue composed of rounded cells.

Mericarp, carpel forming one-half of the fruit of Umbelliferæ.

Merithal, a term used in place of internode; applied by Gaudichaud to the different parts of the leaf.

Mesocarp, middle covering of the fruit.

Mesochilium, middle portion of the labellum of Orchids.

Mesophlœum, middle layer of the bark.

Mesophyllum, the parenchyma of the leaf.

Mesos, the middle, in composition *Meso.*

Mesosperm, applied to a covering of the seed derived from the secundine.

Metre, equal to 39.37079 inches British.

Micrometer, instrument for measuring microscopic objects.

Micropyle, the opening or foramen of the seed.

Micros, small, in composition *Micro.*

Millimetre, equal to 0.03937079 English inch, or 25.39954 millimetres equal to an English inch.

Mitriform, shaped like a mitre, as the calyptræ of some Mosses.

Molecule, an exceedingly minute body in which we cannot discover any determinate external circle nor internal centre.

Monadelphous, stamens united into one bundle by union of their filaments.

Monandrous, having one stamen.

Monembryony, having a single embryo.

Moniliform, beaded, cells united, with interruptions, so as to resemble a string of beads.

Monocarpic, producing flowers and fruit once during life, and then dying.

Monochlamydeous, flower having a single envelope, which is the calyx.

Monoclinous, stamens and pistils in the same flower.

Monocotyledonous, having one cotyledon in the embryo.

Monœcious, stamens and pistils in different flowers on the same plant.

Monogynœcial, applied to simple fruits, formed by the pistil of one flower.

Monogynous, having one pistil or carpel; also applied to plants having one style.

Monopetalous, same as *Gamopetalous.*

Monophyllous, same as *Gamophyllous.*

Monos, one, in composition *Mono* and *Mon*, as *Monandrous*, one stamen; sometimes applied to the union of parts into one, as *Monopetalous*, meaning combined petals; same as Latin *Unus.*

Monosepalous, same as *Gamosepalous.*

Monospermous or **Monospermal**, having a single seed.

Monothecal, having a single loculament.

Monstrosity, an abnormal development, applied more especially to double flowers.

Morphology, the study of the forms which the different organs assume, and the laws that regulate their metamorphoses.

Mucro, a stiff point abruptly terminating an organ; *Mucronate*, having a mucro.

Mucus, definite, peculiar matter forming a covering of certain sea-weeds.

Multicostate, many-ribbed.

Multifid, applied to a simple leaf divided laterally to about the middle into numerous portions; when the divisions extend deeper it is *Multipartite.*

Multilocular, having many loculaments.

Multiple, applied to anthocarpous or polygynœcial fruits formed by the union of several flowers.

Muricate, covered with firm, short points or excrescences.

Muriform, like bricks in a wall; applied to cells.

Muscology, the study of Mosses.

Muticus, without any pointed process or awn.

Mycelium, the cellular spawn of Fungi.

Naked, applied to seeds not contained in a true ovary; also to flowers without any floral envelopes.

Napiform, shaped like a turnip.

Naturalised, originally introduced by artificial means, but become apparently wild.

Navicular, hollowed like a boat.

Nectariferous, having a honey-like secretion; applied to petals having depressions or furrows at their base, which contain a sweet secretion.

Nectary, any abnormal part of a flower. It ought to be restricted to organs secreting a honey-like matter, as in Crown Imperial.

Nervation or **Neuration**, same as *Venation.*

Netted, applied to reticulated venation, also covered with raised lines disposed like the threads of a net.

Nitidus, having a smooth and polished surface.

Node, the part of the stem from which a leaf-bud proceeds.

Nodose, having swollen nodes or articulations.

Nodulose, applied to roots with thickened knots at intervals.

Nosology, vegetable, the study of the diseases of plants.

Notorhizeæ, radicle on the back of the cotyledons, as in some Cruciferæ.

Nucleus, the body which gives origin to new cells; also applied to the central cellular portion of the ovule and seed.

Nuculanium, applied to the fruit of the Medlar having nucules; some also apply this term to the Grape.

Nucule, hard carpel in the Medlar, also one of the parts of fructification in Characeæ.

Nucumentaceous, Cruciferæ having a dry monospermal fruit.

Nut, properly applied to the glans, but also applied to any hard nut-like fruit, as in Carex and Rumex.

Ob, in composition, means reversed or contrariwise.

Obcompressed, flattened in front and behind, not laterally.

Obcordate, inversely heart-shaped, with the divisions of the heart at the opposite end from the stalk.

Oblong, about ¾ as long as broad; elliptical, obtuse at each end.

Obovate, reversely ovate, the broad part of the egg being uppermost.

Obsolete, imperfectly developed or abortive; applied to the calyx when it is in the form of a rim.

Obtuse, not pointed, with a rounded or blunt termination.

Obvolute, margins of one leaf alternately overlapping those of the leaf opposite to it.

Ochrea, boot, applied to the sheathing stipule of Polygonaceæ.

Octandrous, having eight stamens.

Octo, eight, in composition *Oct.*

Octogynous, having eight styles.

Œcium and Œcious, in composition, have reference to the position of the reproductive organs, as *Andrœcium*, the staminal organs; *Diœcious*, stamen and pistil in different flowers.

Officinal, sold in the shops.

Offset, same as *Propagulum*.

Oleraceous, used as an esculent potherb.

Oligandrous, stamens under twenty.

Oligos, few or in small number, in composition *Oligo* and *Olig*.

Omphalode, the central point of the hilum where the nourishing vessels enter.

Oophoridium, organ in Lycopodiaceæ containing large spores.

Opaque, dull, not shining.

Operculum, lid, applied to the separable part of the theca of Mosses; also applied to the lid of certain seed-vessels; *Operculate*, opening by a lid.

Opposite, applied to leaves placed on opposite sides of a stem at the same level.

Orbicular, rounded leaf with petiole attached to the centre of it.

Organogeny, the development of organs.

Organography, the description of the organs of plants.

Orthoploceæ, Cruciferæ having conduplicate cotyledons.

Orthos, straight, in composition *Ortho*, same as Latin *Rectus*.

Orthotropal and Orthotropous, ovule with foramen opposite to the hilum; embryo with radicle next the hilum.

Osmose, the force with which fluids pass through membranes in experiments on exosmose and endosmose.

Oval, elliptical, blunt at each end.

Ovary, the part of the pistil which contains the ovules.

Ovate, shaped like an egg, applied to a leaf with the broader end of the egg next the petiole or axis; *Ovate-lanceolate*, a lanceolate leaf, which is somewhat ovate.

Ovenchyma, tissue composed of oval cells.

Ovule, the young seed contained in the ovary.

Pagina, applied to the surface of the leaf, or any flat surface.

Palæontology, the study of Fossils.

Palæophytology, the study of Fossil plants.

Palate, the projecting portion of the under lip of personate flowers.

Palea or Pale, the part of the flower of Grasses within the glume; also applied to the small scaly laminæ which occur in the receptacle of some Compositæ.

Paleaceous, chaffy, covered with small erect membranous scales.

Palmate and Palmatifid, applied to a leaf with radiating venation, divided into lobes to about the middle.

Palmatipartite, applied to a leaf with radiating venation, cut nearly to the base in a palmate manner.

Panduriform, shaped like a fiddle, applied to an oblong leaf, with a sinus on each side about the middle.

Panicle, inflorescence of Grasses, consisting of spikelets on long peduncles coming off in a racemose manner.

Paniculate, forming a panicle.

Papilionaceous, corolla composed of vexillum, two alæ, and carina, as in the Pea.

Papillated and Papillose, covered with small nipple-like prominences.

Pappus, the hairs at the summit of the ovary in Compositæ. They consist of the altered calycine limb. *Pappose*, provided with pappus.

Paraphyses, filaments, sometimes articulated, occurring in the fructification of Mosses and other Cryptogams; also applied by some authors to abortive petals or stamens.

Parasite, attached to another plant, and deriving nourishment from it.

Parenchyma, cellular tissue.

Parietal, applied to placentas on the wall of the ovary.

Pari-pinnate, a compound pinnate leaf, ending in two leaflets.

Parthenogenesis, production of perfect seed with embryo, without the application of pollen.

Partite or Parted, cut down to near the base, the divisions being called *Partitions*.

Patella, rounded sessile apothecium of Lichens.

Patent, spreading widely.

Pathology, vegetable, same as *Nosology*.

Patulous, spreading less than when patent.

Pectinate, divided laterally into narrow segments, like the teeth of a comb.

Pedate and Pedatifid, a palmate leaf of three lobes, the lateral lobes bearing other equally large lobes on the edges next the middle lobe.

Pedicel, the stalk supporting a single flower; such a flower is *Pedicellate*.

Peduncle, the general flower-stalk or floral axis. Sometimes it bears one flower, at other times it bears several sessile or pedicellate flowers.

Pelagic, growing in many distant parts of the ocean.

Pellicle, the outer cuticular covering of plants.

Peloria, a name given to a teratological phenomenon, which consists in a flower, which is usually irregular, becoming regular; for instance, when Linaria, in place of one spur, produces five.

Peltate, shield-like, fixed to the stalk by a point within the margin; *peltate hairs*, attached by their middle.

Pendulous, applied to ovules which are hung from the upper part of the ovary.

Penicillate, pencilled, applied to a tufted stigma resembling a camel's hair pencil, as in the Nettle.

Penni-nerved and **Penni-veined**, the veins disposed like the parts of a feather, running from the midrib of the leaf to the margin.

Penta, **Pente**, five, same as *Quinque* in Latin.

Pentagynous, having five styles.

Pentamerous, composed of five parts; a pentamerous flower has its different whorls in five, or multiples of that number.

Pentandrous, having five stamens.

Pepo and **Peponida**, the fruit of the Melon, Cucumber, and other Cucurbitaceæ.

Per, when placed before an adjective, sometimes gives it the value of a superlative, as *perpusillus*, very weak; at other times it means through, as *perfoliate*, through the leaf.

Percurrent, running through from top to bottom.

Perennial, living, or rather flowering, for several years.

Perfoliate, a leaf with the lobes at the base, united on the side of the stem opposite the blade, so that the stalk appears to pass through the leaf.

Peri, around; in Latin *Circa*.

Perianth, a general name for the floral envelope; applied in cases where there is only a calyx, or where the calyx and corolla are alike.

Pericarp, the covering of the fruit.

Perichætial, applied to the leaves surrounding the fruit stalk or seta of Mosses

Pericladium, the large sheathing petiole of Umbelliferæ.

Periclinium and **Periphoranthium**, the involucre of Compositæ.

Periderm, a name applied to the outer layer of bark.

Peridium, the envelope of the fructification in Gasteromycetous Fungi.

Perigone, same as Perianth. Some restrict the term to cases in which the flower is female or pistilliferous. It has also been applied to the involucre of Jungermanniceæ.

Perigynium, applied to the covering of the pistil in the genus Carex.

Perigynous, applied to corolla and stamens when attached to the calyx.

Peripherical, applied to an embryo curved so as to surround the albumen, following the inner part of the covering of the seed.

Perisperm, the albumen or nourishing matter stored up with the embryo in the seed.

Perispore, the outer covering of a spore.

Peristome, the opening of the sporangium of Mosses after the removal of the calyptra and operculum.

Perithecium, a conceptacle in Cryptogams, containing spores, and having an opening at one end.

Persistent, not falling off, remaining attached to the axis until the part which bears it is matured.

Personate, a gamopetalous irregular corolla having the lower lip pushed upwards, so as to close the hiatus between the two lips.

Pertuse, having slits or holes.

Perulæ, the scales of the leaf bud.

Petaloid, like a petal.

Petals, the leaves forming the corolline whorl.

Petiolate, having a stalk or petiole.

Petiole, a leaf-stalk; *Petiolule*, the stalk of a leaflet in a compound leaf.

Phanerogamous, having conspicuous flowers.

Phaneros and **Phænos**, conspicuous, in composition *Phanero* and *Phæno*.

Phænogamous, same as *Phanerogamous*.

Phlœum, a name applied in composition to the bark.

Phoranthium, applied to the receptacle of Compositæ.

Phorus, **Phorum**, and **Phore**, in words derived from the Greek, are used as terminations, meaning, that which bears; equivalent to the Latin *Ferus* and *Fer*.

Phragma, transverse division or false dissepiment in fruits.

Phycology, the study of Algæ or Sea-Weeds.

Phyllaries, the leaflets forming the involucre of Composite flowers.

Phyllodium, leaf-stalk enlarged so as to have the appearance of a leaf.

Phylloid, like a leaf.

Phyllolobeæ, cotyledons green and leafy.

Phylloptosis, the fall of the leaf.

Phyllotaxis, the arrangement of the leaves on the axis.

Phyllum, leaf, in composition *Phyllo* and *Phyllous*; in Latin *Folium*.

Physiognomy, general appearance, without reference to botanical characters.

Physiology, Vegetable, the study of the functions of plants.

Phytogenesis, the development of the plant.

Phytography, the description of plants.

Phytology, the study of plants.

Phyton, a name given by Gaudichaud to the simple individual plant, as represented by a leaf. In words derived from the Greek, *Phyton* and *Phyto* mean plant.

Phytozoa, moving filaments in the antheridia of Cryptogams.

Pileorhiza, a covering of the root, as in Lemna.

Pileus, the cap-like portion of the Mushroom, bearing the hymenium on its under side.

Pilose, provided with hairs; applied to pappus composed of simple hairs.

Pinenchyma, tissue composed of tabular cells.

Pinna, the leaflet of a pinnate leaf.

Pinnate, a compound leaf having leaflets arranged on each side of a central rib.

Pinnatifid, a simple leaf cut into lateral segments to about the middle.

Pinnatipartite, a simple leaf cut into lateral segments, the divisions extending nearly to the central rib.

Pinnule, the small pinnæ of a bipinnate or tripinnate leaf.

Pistil, the female organ of the flower, composed of one or more carpels; each carpel being composed of ovary, style, and stigma.

Pistillate and **Pistilliferous**, applied to a female flower or a female plant.

Pistillidium, the female organ in Cryptogams.

Placenta, the cellular part of the carpel bearing the ovule.

Placentary, a placenta bearing numerous ovules.

Placentation, the formation and arrangement of the placenta.

Platys, large or broad; in composition *Platy;* in Latin *Latus* and *Late*.

Pleion, several, in composition *Pleio;* in Latin *Pluri*.

Pleiotracheæ, spiral vessels with several fibres united.

Plenus, when applied to the flower, means double.

Pleurenchyma, woody tissue.

Pleurocarpi, Mosses with the fructification proceeding laterally from the axils of the leaves.

Pleurorhizeæ, Cruciferous plants having the radicle of the embryo applied to the edges of the cotyledons, which are called *Accumbent*.

Plicate and **Plicative**, plaited or folded like a fan.

Plumose, feathery, applied to hairs having two longitudinal rows of minute cellular processes.

Plumule, the first-bud of the embryo, usually enclosed by the cotyledons.

Pluri, in Latin words means several.

Plurilocular, having many loculaments.

Podetium, a stalk bearing the fructification in some Lichens.

Podocarp, a stalk supporting the fruit.

Podogynium, a stalk supporting an ovary.

Podosperm, the cord attaching the seed to the placenta.

Pogon, beard; in Latin *Barba*.

Pollard-trees, cut down so as to leave only the lower part of the trunk, which gives off numerous buds and branches.

Pollen, the powdery matter contained in the anther.

Pollen-tube, the tube emitted by the pollen-grain after it is applied to the stigma.

Pollinia, masses of pollen found in Orchids and Asclepiads.

Polyadelphous, stamens united by their filaments so as to form more than two bundles.

Polyandrous, stamens above twenty.

Polycarpic, plants which flower and fruit many times in the course of their life.

Polycotyledonous, an embryo having many cotyledons, as in Firs.

Polyembryony, having more than one embryo.

Polygamous, plants bearing hermaphrodite as well as male and female flowers.

Polygynœcial, applied to multiple fruits formed by the united pistils of many flowers.

Polygynous, having many pistils or styles.

Polymorphous, assuming many shapes.

Polypetalous, a corolla composed of separate petals.

Polyphyllous, a calyx or involucre composed of separate leaflets.

Polys, many, in composition Poly; in Latin *Multus*.

Polysepalous, a calyx composed of separate sepals.

Polyspermal, containing many seeds.

Pome, a fruit like the Apple and Pear.

Pores of the leaf, same as *Stomata*.

Porous vessels, same as Pitted or Dotted vessels.

Porrect, extended forwards.

Posterior, applied to the part of the flower placed next the axis; same as *Superior*.

Posticus, same as *Extrorse;* applied to anthers.

Pouch, the short pod or silicle of some Crucifers.

Pous, **Podos**, a foot or stalk, in composition *Podo;* in Latin *Pes*, *Pedis*.

Præfloration, same as *Æstivation*.

Præfoliation, same as *Vernation*.

Premorse, bitten, applied to a root terminating abruptly, as if bitten off.

Prickles, hardened epidermal appendages, of a nature similar to hairs.

Primine, the outer coat of the ovule.

Primordial, the first true leaves given off by the young plant; also the first fruit produced on a raceme or spike.

Primordial Utricle, the lining membrane of cells in their early state.

Prismenchyma, tissue composed of prismatical cells.

Process, any prominence or projecting part, or small lobe.

Procumbent, lying on the ground.

Pro-embryo, cellular body in ovary, from which the embryo and its suspensor are formed. Sometimes *Pro-embryo* is used for *Prothallus*.

Proliferous, bearing abnormal buds.

Prone, prostrate, lying flat on the earth.

Propagulum, an off-shoot, or germinating bud attached by a thickish stalk to the parent plant.

Prosenchyma, fusiform tissue forming wood.

Prothallium or **Prothallus**, names given to the first part produced by the spore of an acrogen in germinating.

Protoplasm, the matter which seems to be concerned in the early formation of nuclei and cells.

Pruinose, covered with a coarse granular secretion, as if dusted.

Pseudo, false; in Latin, *Spurius*.

Pseudo-bulb, the peculiar aerial stem of many epiphytic Orchids.

Pseudo-spermous, applied to plants bearing single-seeded seed-vessels, such as Achenes, resembling seeds.

Pteridographia, a treatise on Ferns.

Pterocarpus, winged fruit.

Pubescence, short and soft hairs covering a surface, which is hence called *Pubescent*.

Pulverulent, covered with fine powdery matter.

Pulvinate, shaped like a cushion or pillow.

Pulvinus, cellular swelling at the point where the leaf-stalk joins the axis.

Punctated, applied to the peculiar dotted woody fibres of Coniferæ.

Putamen, the hard endocarp of some fruits.

Pycnide, a papillæform or wart-like simple cellular reproductive body in the thallus of Lichens.

Pyrenæ, stony coverings of the seeds in the Medlar.

Pyridium, same as *Pome.*

Pyriform, pear-shaped.

Pyxis and **Pyxidium**, a capsule opening by a lid.

Quadri, in composition means four times.

Quadrifarious, in four rows.

Quadrifid, four-cleft, cut down into four parts to about the middle.

Quadrijugate, having four pairs of leaflets.

Quadrilocular, having four loculaments.

Quadripartite, divided deeply into four parts.

Quartine, the fourth coat of the ovule, which often is changed into albumen.

Quaternate, leaves coming off in fours from one point.

Quinary, composed of five parts, or of a multiple of five.

Quinate, five leaves coming off from one point.

Quincunx, when the leaves in the bud are five, of which two are exterior, two interior, and the fifth covers the interior with one margin, and has its other margin covered by the exterior. *Quincuncial*, arranged in a quincunx.

Quinque, in compound words means five.

Quinquefid, five-cleft, cut into five parts as far as the middle.

Quinquelocular, having five loculaments.

Quinquepartite, divided deeply into five parts.

Quintine, the fifth coat of the ovule, otherwise called the embryo-sac.

Race, a permanent variety.

Raceme, cluster, inflorescence in which there is a primary axis bearing stalked flowers.

Racemose, flowering in racemes.

Rachis, the axis of inflorescence; also applied to the stalk of the frond in Ferns, and to the common stalk bearing the alternate spikelets in some Grasses.

Radiant, applied to flowers which form a ray-like appearance, as seen in Umbelliferæ and in Viburnum, &c.

Radiate, disposed like the spokes of a wheel; also applied to the florets of the ray or circumference of the capitula of Compositæ.

Radical, belonging to the root, applied to leaves close to the ground, clustered at the base of a flower stalk.

Radicle, the young root of the embryo.

Radius, the ray or outer part of the heads of Composite flowers.

Ramal, belonging to the branches.

Ramenta, the scales or chaff of Ferns.

Ramose and **Ramous**, branched.

Raphe, the line which connects the hilum and the chalaza in anatropal ovules.

Raphides, crystals found in cells, which are hence called *Raphidian.*

Receptacle, the flattened end of the peduncle or rachis, bearing numerous flowers in a head; applied also generally to the extremity of the peduncle or pedicel.

Reclinate, curved downwards from the horizontal, bent back up.

Rectembryeæ, the embryo straight in the axis of the seed.

Rectinervis and **Rectivenius**, straight and parallel-veined.

Rectiserial, leaves disposed in a rectilinear series.

Recurved, bent backwards.

Reduplicate, edges of the sepals or petals turned outwards in æstivation.

Regma, seed-vessel composed of elastic cocci, as in Euphorbia.

Regular, applied to an organ, the parts of which are of similar form and size.

Reliquiæ, remains of withered leaves attached to the plant.

Reniform, in shape like a kidney.

Repand, having a slightly undulated or sinuous margin.

Replum, a longitudinal division in a pod formed by the placenta, as in Cruciferæ.

Resupinate, inverted by a twisting of the stalk.

Reticulated, netted, applied to leaves having a network of anastomosing veins.

Retiform, like network.

Retinaculum, the glandular viscid portion at the extremity of the caudicle in some pollinia.

Retinervis and **Retivenius**, having reticulated veins.

Retrorse, turned backwards.

Retuse, when the extremity is broad, blunt, and slightly depressed.

Revolute and **Revolutive**, leaf with its edges rolled backwards in vernation.

Rhiza, in words derived from the Greek, means root.

Rhizome, a stem creeping horizontally, more or less covered by the soil, giving off buds above, and roots below.

Rhizotaxis, the arrangement of the roots.

Rhomboid, quadrangular form, not square, with equal sides.

Rictus, the throat or chink in personate flowers.

Ringent, a Labiate flower, in which the upper lip is much arched.

Rosaceous, applied to corollas having separate sessile petals like the Rose.

Rosette, leaves disposed in close circles forming a cluster.

Rostellum, a prolongation of the upper edge of the stigma in some Orchids.

Rostrate, beaked, having a long sharp point.

Rotate, a regular gamopetalous corolla with a short tube, the limb spreading out more or less at right angles.

Rotation or **Gyration**, a peculiar circulation of the cell sap, seen in Hydrocharidaceæ, &c.

Root-stock, same as *Rhizome.*

Rudimentary, an organ in an abortive state arrested in its development.

Rugose, wrinkled.

Ruminate, applied to mottled albumen.

Runcinate, a pinnatifid leaf with a triangular termination, and sharp divisions pointing downwards, as in Dandelion.

Saccate, forming a sack or bag, seen in some petals.

Sagittate, like an arrow, a leaf having two prolonged sharp-pointed lobes projecting downwards beyond the insertion of the petiole.

Samara, a winged dry fruit, as in the Elm.

Sarcocarp and **Sarcoderm**, the mesocarp of the fruit having become succulent.

Sarcolobeæ, cotyledons thick and fleshy, as in Bean and Pea.

Sarmentum, sometimes meaning the same as *Flagellum*, or runner, at other times applied to a twining stem which supports itself by means of others.

Scabrous, rough, covered with very stiff short hairs; *Scabriusculus*, somewhat rough.

Scalariform, vessels having bars like a ladder, seen in Ferns.

Scandent, climbing by means of supports, as on a wall or rock.

Scape, a naked flower-stalk, bearing one or more flowers arising from a short axis, and usually with radical leaves at its base.

Scarious, having the consistence of a dry scale, membranous, dry, and shrivelled.

Scion, the young twig used as a graft.

Sclerogen, the thickening matter of woody cells.

Scobiform, in the form of filings, or like fine sawdust.

Scobina, the flexuose rachis of some Grasses.

Scorpioidal, like the tail of a scorpion, a peculiar twisted cymose inflorescence, as in Boraginaceæ.

Scrobiculate, pitted, having small depressions.

Scutellum, a sort of apothecium in Lichens.

Secund, turned to one side.

Secundine, the second coat of the ovule within the primine.

Segregate, separated from each other.

Semi, half, same as the Greek *Hemi*.

Semiflosculous, same as *Ligulate*.

Seminal, applied to the cotyledons, or seed-leaves.

Sepal, one of the leaflets forming the calyx.

Septate, divided by septa or partitions.

Septem, seven, in Greek *Hepta*.

Septenate, organs approaching in sevens; a compound leaf with seven leaflets coming off from one point.

Septicidal, dehiscence of a seed-vessel through the septa or edges of the carpels.

Septifragal, dehiscence of a seed-vessel through the back of the loculaments, the valves also separating from the septa.

Septulate, having spurious transverse dissepiments.

Septum, a division in an ovary formed by the sides of the carpels.

Sericeous, silky, covered with fine, close-pressed hairs.

Serrate or **Serrated**, having sharp processes arranged like the teeth of a saw. *Biserrate*, when these are alternately large and small, or where the teeth are themselves serrated.

Serratures, pointed marginal divisions arranged like the teeth of a saw.

Serrulate, with very fine serratures.

Sesqui, in composition, means one and a half.

Sessile, without a stalk, as a leaf without a petiole.

Seta, a bristle or sharp hair; also applied to the gland-tipped hairs of Rosaceæ and Hieracia; and to the stalk bearing the theca in Mosses.

Setaceous and **Setiform**, in the form of bristles.

Setigerous, bearing setæ.

Setose, covered with setæ.

Sex, in Latin six, same as Greek *Hexa*.

Silicula or **Silicle**, a short pod with a double placenta and replum, as in some Cruciferæ.

Siliculosæ, bearing a silicle.

Siliqua, a long pod similar in structure to the silicula.

Siliquæform, fruit like a siliqua in form.

Siliquosæ, bearing a siliqua.

Simple, not branching, not divided into separate parts; *Simple fruits* are those formed by one flower.

Sinistrorse, directed towards the left.

Sinuated, the margin having numerous large obtuse indentations.

Sinuous, with a wavy or flexuous margin.

Slashed, divided by deep and very acute incisions.

Soboles, a creeping under-ground stem.

Social Plants, such as grow naturally in groups or masses.

Soredia, powdery cells on the surface of the thallus of some Lichens.

Sorosis, a compound or polygynœcial succulent fruit, such as Breadfruit and Mulberry.

Sorus, a cluster of sporangia in Ferns; applied also to fructification in Alaria, containing pyriform stipitate spores.

Spadix, a succulent spike bearing male and female flowers, as in Arum.

Spathaceous, having the aspect and membranous consistence of a spathe.

Spathe, large membranous bract covering numerous flowers.

Spathellæ, another name for the glumellæ of Grasses.

Spathulate, shaped like a spathula, applied to a leaf having a linear form, enlarging suddenly into a rounded extremity.

Spawn, same as *Mycelium*.

Specific Character, the essential character of a species.

Spermatia, motionless spermatozoids in the spermogones of Lichens and Fungi.

Spermatozoids, moving filaments contained in the antheridia of Cryptogams; called also phytozoa and antherozoids.

Spermoderm, the general covering of the seed. Sometimes applied to the episperm or outer covering.

Spermogone, a microscopic conceptacle in Lichens, containing reproductive bodies called Spermatia; also a conceptacle containing fructification in Fungi.

Sphærenchyma, tissue composed of spherical cells.

Spike, inflorescence consisting of numerous flowers sessile on an axis.

Spikelet, small cluster of flowers in Grasses.

Spine or **Thorn**, an abortive branch with a hard sharp point.

Spinescent or **Spinose**, bearing spines.

Spiral Vessels or **Spiroidea**, having a spiral fibre coiled up inside a tube.

Spirillum, same as *Spermatozoid*.

Spirolobeæ, Cruciferæ having the cotyledons folded transversely, the radicle being dorsal.

Spongiole or **Spongelet**, the cellular extremity of a young root.

Sporangium, a case containing spores.

SPORE, a cellular germinating body in Cryptogamic plants.

SPORIDIUM, a cellular germinating body in Cryptogamics containing two or more cells in its interior.

SPOROCARP, the involucre or ovoid-sac containing the organs of reproduction in Marsileaceæ.

SPOROPHORE, a stalk supporting a spore.

SPOROZOID, a moving spore furnished with cilia or vibratile processes.

SPUR, same as *Calcar*.

SQUAMA, a scale; also applied to bracts on the receptacle of Compositæ, to bracts in the inflorescence of Amentiferæ, and to the lodiculæ of Grasses.

SQUAMOSE, covered with scales.

SQUARROSE, covered with processes spreading at right angles or in a greater degree.

STACHYS and STACHYA, in Greek words signify a spike.

STAMEN, the male organ of the flower, formed by a stalk or filament and the anther containing pollen.

STAMINATE and STAMINIFEROUS, applied to a male flower, or to plants bearing male flowers.

STAMINODIUM, an abortive stamen.

STANDARD, same as *Vexillum*.

STELLATE or STELLIFORM, arranged like a star.

STERIGMATA, cells bearing naked spores; also cellular filaments bearing spermatia and stylospores, in the Spermogones and Pycnides of Lichens.

STERILE, male flowers not bearing fruit.

STICHIDIA, pod-like receptacles containing spores.

STICHOUS, at the termination of words means a row, as *distichous*, in two rows.

STIGMA, the upper cellular secreting portion of the pistil, uncovered with epidermis; *Stigmatic*, belonging to the stigma.

STIMULUS, a sting, applied to stinging hairs with an irritating secretion at the base.

STIPE, the stem of Palms and of Tree-ferns; also applied to the stalk of Fern-fronds, and to the stalk bearing the pileus in Agarics.

STIPEL, a small leaflet at the base of the pinnæ or pinnules of compound leaves.

STIPITATE, supported on a stalk.

STIPULARY, applied to organs occupying the place of stipules, such as tendrils.

STIPULATE, furnished with stipules.

STIPULE, leaflet at the base of other leaves, having a lateral position, and more or less changed either in form or texture.

STOLON, a sucker, at first aerial, and then turning downwards and rooting.

STOLONIFEROUS, having creeping runners which root at the joints.

STOOL, a plant from which layers are propagated, by bending down the branches so as to root in the soil.

STOMATES and STOMATA, openings in the epidermis of plants, especially in the leaves.

STRANGULATED, contracted and expanded irregularly.

STRAP-SHAPED, same as *Ligulate;* linear, or about six times as long as broad.

STRIA, a narrow line or mark.

STRIATED, marked by streaks or striæ.

STRIGOSE, covered with rough, strong, adpressed hairs.

STROBILUS, a cone, applied to the fruit of Firs as well as to that of the Hop.

STROPHIOLE, a sort of aril or swelling on the surface of a seed.

STRUMA, a cellular swelling at the point where a leaflet joins the midrib; also a swelling below the sporangium of Mosses.

STUPOSE, having a tuft of hairs.

STYLE, the stalk interposed between the ovary and the stigma.

STYLOPOD, an epigynous disk seen at the base of the styles of Umbelliferæ.

STYLOSPORE, a spore-like body borne on a sterigma or cellular stalk, in the Pycnides of Lichens.

SUBEROUS, having a corky texture.

SUBICULUM, same as *Hypothallus*.

SUBTERRANEAN, under ground, same as *Hypogeal*.

SUBULATE, shaped like a cobbler's awl.

SUCCISUS, abrupt, as it were cut off, same as *Premorse*.

SUFFRUTICOSE, having the characters of an undershrub.

SULCATE, furrowed or grooved.

SUPERIOR, applied to the ovary when free or not adherent to the calyx; to the calyx when it is adherent to the ovary; to the part of a flower placed next the axis.

SUPERVOLUTE or SUPERVOLUTIVE, a leaf rolled upon itself in vernation.

SURCULUS, a sucker, a shoot thrown off underground, and only rooting at its base.

SUSPENDED, applied to an ovule which hangs from a point a little below the apex of the ovary.

SUSPENSOR, the cord which suspends the embryo, and is attached to the radicle in the young state.

SUTURAL, applied to that kind of dehiscence which takes place at the sutures of the fruit.

SUTURE, the part where separate organs unite, or where the edges of a folded organ adhere; the *ventral suture* of the ovary is that next the centre of the flower; the *dorsal suture* corresponds to the midrib.

SYCONUS, a multiple or polygynœcial succulent hollow fruit, as in the Fig.

SYMMETRY, applied to the flower, has reference to the parts being of the same number, or multiples of each other.

SYN, in composition means united.

SYNANTHEROUS, anthers united.

SYNANTHOS, flowers united together.

SYNCARPOUS, carpels united so as to form one ovary or pistil.

SYNGENESIOUS, same as *Synantherous*.

SYNOCHREATE, stipules uniting together on the opposite side of the axis from the leaf.

TAPHRENCHYMA, pitted vessels, same as *Bothrenchyma*.

TAP-ROOT, root descending deeply in a tapering undivided manner.

TAXONOMY, principles of the classification of plants.

TEGMEN, the second covering of the seed, called also *Endopleura*.

TEGMENTA, scales protecting buds.

Teratology, study of monstrosities and morphological changes.

Tercine, the third coat of the ovule, forming the covering of the central nucleus.

Terete, nearly cylindrical, somewhat tapering into a very elongated cone, the transverse section nearly circular.

Ternary, parts arranged in threes.

Ternate, compound leaves composed of three leaflets.

Testa, the outer covering of the seed; some apply it to the coverings taken collectively.

Testiculate, root having two oblong tubercules.

Tetra, in Greek words four; in Latin *Quater* or *Quadri*.

Tetradynamous, four long stamens and two short, as in Cruciferæ.

Tetragonous or Tetragonal, having four angles, the faces being convex.

Tetragynous, having four carpels or four styles.

Tetramerous, composed of four parts; a flower is tetramerous when its envelopes are in fours, or multiples of that number.

Tetrandrous, having four stamens.

Tetrapterous, having four wings.

Tetraquetrous, having four angles, the faces being concave.

Tetraspore, a germinating body in Algæ composed of four spore-like cells; but also applied to those of three cells.

Tetrathecal, having four loculaments.

Thalamifloral, parts of the floral envelope inserted separately into the receptacle of thalamus.

Thalamus, the receptacle of the flower, or the part of the peduncle into which the floral organs are inserted.

Thallogens or Thallophytes, plants producing a thallus.

Thallus, cellular expansion in Lichens and other Cryptogams, bearing the fructification.

Theca, sporangium or spore-case containing spores.

Thecaphore, a stalk supporting the ovary.

Thecasporous, applied to Fungi which have the spores in thecæ.

Throat, the orifice of a gamopetalous flower.

Thyrsus, a sort of panicle, in form like a bunch of grapes, the inflorescence being mixed.

Tigellus, the young embryonic axis.

Toise, is equal to 1.94904 metres or 6.39459 English feet.

Tomentose, covered with cottony, entangled pubescence called *tomentum*.

Torulose, presenting successive rounded swellings, as in the moniliform pods of some Cruciferæ.

Torus, another name for thalamus; sometimes applied to a much developed thalamus, as in Nelumbium.

Tracheæ, a name for spiral vessels.

Trachenchyma, tissue composed of spiral vessels.

Transpiration, the exhalation of fluids by leaves, &c.

Treis, three; Tris, thrice, in composition *Tri*.

Triadelphous, stamens united in three bundles by their filaments.

Triandrous, having three stamens.

Triangular, having three angles, the faces being flat.

Trichotomous, divided successively into three branches.

Tricoccous, formed by three elastic monospermal carpels.

Tricostate, three-ribbed, ribs from the base.

Tricuspidate, having three long points or cuspides.

Tridentate, having three teeth.

Trifarious, in three rows, looking in three directions.

Trifid, three-cleft, a leaf divided into three segments which reach to the middle.

Trifoliate or Trifoliolate, same as *Ternate*. When the three leaves come off at one point the leaf is *ternately-trifoliolate*; when there is a terminal stalked leaflet and two lateral ones it is *pinnately-trifoliolate*.

Trigonous, having three angles, the faces being convex.

Trigynous, having three carpels or three styles.

Trijugate, having three pairs of leaflets.

Trilocular, having three loculaments.

Trimerous, composed of three parts; *a trimerous flower* has its envelopes in three or multiples of three.

Trinervis, having three ribs springing together from the base.

Trioecious, a species producing hermaphrodite, staminate, and pistillate flowers on three separate individuals.

Tripartite, deeply divided into three.

Tripinnate, a compound leaf three times divided in a pinnate manner.

Tripinnatifid, a pinnatifid leaf with the segments twice divided in a pinnatifid manner.

Triplicostate, three ribs proceeding from above the base of the leaf.

Triquetrous, having three angles, the faces being concave.

Tristichous, in three rows.

Triternate, three times divided in a ternate manner.

Trophosperm, a name for the placenta.

Truncate, terminating abruptly, as if cut off at the end.

Tryma, drupaceous fruit like the Walnut.

Tuber, a thickened underground stem as the potato.

Tubercule, the swollen root of some terrestrial Orchids.

Tuberous, applied to roots in the form of tubercules.

Tubular, applied to the regular florets of the Compositæ.

Tubular-bell-shaped, applied to a campanulate corolla, which is somewhat tubular in its form.

Tunicated, applied to a bulb covered by thin external scales, as the Onion.

Turbinate, in the form of a top.

Turio, a young shoot covered with scales sent up from an underground stem, as in Asparagus.

Type, the perfect representation or idea of anything.

Typical, applied to a specimen which has eminently the characteristics of the species, or to a species or genus characteristic of an order.

UMBEL, inflorescence in which numerous stalked flowers arise from one point.

UMBELLULE, a small umbel, seen in the compound umbellate flowers of many Umbelliferæ.

UMBILICATE, fixed to a stalk by a point in the centre.

UMBILICUS, the hilum or base of a seed.

UMBO, a conical protuberance on a surface.

UMBONATE, round, with a projecting point in the centre, like the boss of an ancient shield.

UMBRACULIFEROUS, in the form of an expanded umbrella.

UNCINATE, provided with an *uncus* or hooked process.

UNDECIM, eleven, in Greek *Endeca.*

UNGUIS, claw, the narrowed part of a petal; such a petal is called *Unguiculate.*

UNI, in composition one, same as Greek *Mono.*

UNICELLULAR, composed of a single cell, as some Algæ.

UNILATERAL, arranged on one side, or turned to one side.

UNILOCULAR, having a single *loculus* or cavity.

UNISEXUAL, of a single sex, applied to plants having separate male and female flowers.

URCEOLATE, urn-shaped, applied to a gamopetalous globular corolla, with a narrow opening.

USTULATE, blackened.

UTRICLE, a name for a thin-walled cell, or for a bladder-like covering.

UTRICULUS, applied to a kind of fruit like the achene, but with an inflated covering; also to the persistent confluent perigone of Carex; in Algæ applied to a loose cellular envelope containing spores.

VAGINA, sheath, lower sheathing portion of some leaves.

VALLECULA, an interval between the ribs on the fruit of Umbelliferæ.

VALVATE, opening by valves, like the parts of certain seed-vessels, which separate at the edges of the carpels.

VALVATE ÆSTIVATION and VERNATION, when leaves in the flower-bud and leaf-bud are applied to each other by their margins only.

VALVES, the portions which separate in some dehiscent capsules. A name also given to the parts of the flower of grasses.

VASCULAR TISSUE, composed of spiral vessels and their modifications.

VASIFORM TISSUE, same as *Dotted vessels.*

VEINS, bundles of vessels in leaves.

VELUM, veil, the cellular covering of the gills of an Agaric, in its early state.

VELUTINOUS, having a velvety appearance.

VENATION, the arrangement of the veins.

VENTRAL, applied to the part of the carpel which is next the axis.

VENTRICOSE, swelling unequally on one side.

VERMICULAR, shaped like a worm.

VERNATION, the arrangement of the leaves in the bud.

VERRUCOSE, covered with wart-like excrescences.

VERSATILE, applied to an anther which is attached by one point of its back to the filament, and hence is very easily turned about.

VERTICIL, a whorl, parts arranged opposite to each other at the same level, or, in other words, in a circle round an axis. The parts are said to be *Verticillate.*

VERTICILLASTER, a false whorl, formed of two nearly sessile cymes placed in the axils of opposite leaves, as in Dead-nettle.

VESICLE, another name for a cell or utricle.

VESSELS, tubes with closed extremities.

VEXILLARY, applied to æstivation when the vexillum is folded over the other parts of the flower.

VEXILLUM, standard, the upper or posterior petal of a papilionaceous flower.

VIGINTI, twenty; same as Greek *Icosi.*

VILLOUS, covered with long soft hairs, and having a woolly appearance.

VIRGATE, long and straight like a wand.

VISCOUS, clammy, like bird-lime.

VITELLUS, the embryo-sac when persistent in the seed.

VITTÆ, cells or clavate tubes containing oil in the pericarp of Umbelliferæ.

VIVIPAROUS, plants producing leaf-buds in place of fruit

VOLUBILE, twining, a stem or tendril twining round other plants.

VOLVA, wrapper, the organ which encloses the parts of fructification in some Fungi in their young state.

WHORLED, same as *Verticillate.*

WINGS, the two lateral petals of a papilionaceous flower, or the broad flat edge of any organ.

XANTHOPHYLL, yellow colouring matter in plants.

XANTHOS, yellow, in composition *Xantho.*

XYLOCARPOUS, fruit which becomes hard and woody.

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ZOOTHECA, a cell containing a spermatozoid.

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Tripartite, deeply divided into three.

Tripinnate, a compound leaf three times divided in a pinnate manner.

Tripinnatifid, a pinnatifid leaf with the segments twice divided in a pinnatifid manner.

Triplicostate, three ribs proceeding from above the base of the leaf.

Triquetrous, having three angles, the faces being concave.

Tristichous, in three rows.

Triternate, three times divided in a ternate manner.

Trophosperm, a name for the placenta.

Truncate, terminating abruptly, as if cut off at the end.

Tryma, drupaceous fruit like the Walnut.

Tuber, a thickened underground stem as the potato.

Tubercule, the swollen root of some terrestrial Orchids.

Tuberous, applied to roots in the form of tubercules.

Tubular, applied to the regular florets of the Compositæ.

Tubular-bell-shaped, applied to a campanulate corolla, which is somewhat tubular in its form.

Tunicated, applied to a bulb covered by the external scales, as the Onion.

Turbinate, in the form of a top.

Turio, a young shoot covered with scales and up from an underground stem, as in Asparagus.

Type, the perfect representation or idea of anything.

Typical, applied to a specimen which has eminently the characteristics of the species, or to a species or genus characteristic of an order.

UMBEL, inflorescence in which numerous stalked flowers arise from one point.
UMBELLULE, a small umbel, seen in the compound umbellate flowers of many Umbelliferæ.
UMBILICATE, fixed to a stalk by a point in the centre.
UMBILICUS, the hilum or base of a seed.
UMBO, a conical protuberance on a surface.
UMBONATE, round, with a projecting point in the centre, like the boss of an ancient shield.
UMBRACULIFEROUS, in the form of an expanded umbrella.
UNCINATE, provided with an *uncus* or hooked process.
UNDECIM, eleven, in Greek *Endeca*.
UNGUIS, claw, the narrowed part of a petal; such a petal is called *Unguiculate*.
UNI, in composition one, same as Greek *Mono*.
UNICELLULAR, composed of a single cell, as some Algæ.
UNILATERAL, arranged on one side, or turned to one side.
UNILOCULAR, having a single *loculus* or cavity.
UNISEXUAL, of a single sex, applied to plants having separate male and female flowers.
URCEOLATE, urn-shaped, applied to a gamopetalous globular corolla, with a narrow opening.
USTULATE, blackened.
UTRICLE, a name for a thin-walled cell, or for a bladder-like covering.
UTRICULUS, applied to a kind of fruit like the achene, but with an inflated covering; also to the persistent confluent perigone of Carex; in Algæ applied to a loose cellular envelope containing spores.

VAGINA, sheath, lower sheathing portion of some leaves.
VALLECULA, an interval between the ribs on the fruit of Umbelliferæ.
VALVATE, opening by valves, like the parts of certain seed-vessels, which separate at the edges of the carpels.
VALVATE ÆSTIVATION and VERNATION, when leaves in the flower-bud and leaf-bud are applied to each other by their margins only.
VALVES, the portions which separate in some dehiscent capsules. A name also given to the parts of the flower of grasses.
VASCULAR TISSUE, composed of spiral vessels and their modifications.
VASIFORM TISSUE, same as *Dotted vessels*.
VEINS, bundles of vessels in leaves.
VELUM, veil, the cellular covering of the gills of an Agaric, in its early state.
VELUTINOUS, having a velvety appearance.
VENATION, the arrangement of the veins.
VENTRAL, applied to the part of the carpel which is next the axis.
VENTRICOSE, swelling unequally on one side.
VERMICULAR, shaped like a worm.
VERNATION, the arrangement of the leaves in the bud.
VERRUCOSE, covered with wart-like excrescences.
VERSATILE, applied to an anther which is attached by one point of its back to the filament, and hence is very easily turned about.
VERTICIL, a whorl, parts arranged opposite to each other at the same level, or, in other words, in a circle round an axis. The parts are said to be *Verticillate*.
VERTICILLASTER, a false whorl, formed of two nearly sessile cymes placed in the axils of opposite leaves, as in Dead-nettle.
VESICLE, another name for a cell or utricle.
VESSELS, tubes with closed extremities.
VEXILLARY, applied to æstivation when the vexillum is folded over the other parts of the flower.
VEXILLUM, standard, the upper or posterior petal of a papilionaceous flower.
VIGINTI, twenty; same as Greek *Icosi*.
VILLOUS, covered with long soft hairs, and having a woolly appearance.
VIRGATE, long and straight like a wand.
VISCOUS, clammy, like bird-lime.
VITELLUS, the embryo-sac when persistent in the seed.
VITTÆ, cells or clavate tubes containing oil in the pericarp of Umbelliferæ.
VIVIPAROUS, plants producing leaf-buds in place of fruit
VOLUBILE, twining, a stem or tendril twining round other plants.
VOLVA, wrapper, the organ which encloses the parts of fructification in some Fungi in their young state.

WHORLED, same as *Verticillate*.
WINGS, the two lateral petals of a papilionaceous flower, or the broad flat edge of any organ.

XANTHOPHYLL, yellow colouring matter in plants.
XANTHOS, yellow, in composition *Xantho*.
XYLOCARPOUS, fruit which becomes hard and woody.

ZOOSPORE, a moving spore provided with cilia; called also *Zoosperm* and *Sporozoid*.
ZOOTHECA, a cell containing a spermatozoid.

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